ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XLVII. No. 12.

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A MARINE-BOILER OIL-BURNING LOCOMOTIVE o curious design has been put in service on the North Pacific Coast Ry. The boiler is 19 ft. 6 ins. long, including the smokebox, and contains a Morison corrugated furnace 42 ins. diameter, with 49 water tubes 3 ins. diameter extending through the furnace. The dome is a horizontal drum over the firebox end of the boiler, connected to the boiler by three flanged openings or legs, and the feed water is delivered into this drum, which has a scale collecting device, with blow-off. The boiler is set on the frame and running gear of a Baldwin eight-wheel engine. It is placed, however, with its firebox and steam drum over the truck, this end of the engine having the cab, with the idea of giving the men a better view of the road, but the effect is to place an undue proportion of the weight on the truck and to correspondingly lighten the weight on the driving wheels. The boiler is set higher at the firebox end than at the smokebox end, in order to facilitate circulation in the water tubes. The sandbox is placed between the frames. The oil fuel is heated by the exhaust steam and is sprayed into the firebox by a Jones & Jover "Sunlight" burner; no brickwork is used. The tender consists of an ordinary tender frame and trucks, with two upright cylindrical tanks, one holding 1,000 gallons of oil and the other 1,200 gallons of water. The designs for this engine were evolved by Mr. J. B. Stetson, President, and Mr. W. L. Thomas, Master Mechanic, of the railway. The line is of 3 ft. gage, and only 108 miles in length.

BOX CARS WITH RIVETED TRUSSES, instead of the usual arrangement of truss rods and struts, are being experimented with on the Atchison, Topeka & Santa Fe Ry., and were built at the company's shops from the designs of Mr. George R. Henderson, Superintendent of Motive Power. The cars are 36 ft. long over the sills and of 80,000 lbs. capacity, weighing 38,150 lbs. empty. The side sills are 10-in. steel channels with the flanges inward, and having outside wooden sills 3 × 10½ ins., to which the flooring and sheathing are nailed. The center sills are 12-in. channels, set back to back, 14 ins. apart, with diagonal bracing between them. These are set 4 ins. below the level of the side sills in order to carry 4-in. wooden nailing strips. The bolsters are of plate-girder construction, and the transoms are similar, but with web diagonals. The struts are plates riveted to the sills, and the bottom chord of each truss is formed by a bar ½ × 3½ ins., riveted to the sills and struts, the truss depth being 24 ins. The posts are I-beams with wooden diagonals and top plates.

A LOCOMOTIVE COALING STATION has recently been erected for the Baltimore & Ohio R. R. at Hyndman, Pa., and is a two-pocket coaling station and ash-handling plant combined. The capacity of each coal pocket is 50 tons, and under the pockets are storage bins of 70 tons capacity, while the coal-receiving pit holds 55 tons, making a total capacity of 295 tons. The elevating machinery is capable of elevating 50 tons per hour of ordinary mine-run coal. The coal buckets, receiving pit, elevator troughs and chutes in which the coal is conveyed to the pockets from the elevator buckets are all lined with steel. Hinged steel aprons lead from the pockets to the engine tenders, and the openings through which the coal runs from the pockets to the aprons have heavy steel gates equipped with friction rollers running in guides. The operation of the gate is such that any desired quantity of coal can be taken from the pocket, and it will shut off the flow of coal without waste or delay. The ash pit is of sufficient length to allow locomotives to dump ashes while taking coal when headed in either direction, and the ash-handling plant has a capacity of about 30 tons per hour. The ash hopper or bin, which is located directly over the coal-receiving track, has a capacity of 50 tons. The plant was installed by the Fairbanks & Morse Co., of Chicago, and the coal-elevating machinery is driven by one of this company's 12-HP. gasoline engines.

TREE PLANTING by railways, park boards, municipal authorities and private parties, in order to provide a supply of timber for ties, fence, posts, mine timbering, etc., and thus to check the destruction of the remaining forest resources, is the aim of the International Society of Arboriculture, which also endeavors to arouse general interest in the planting of trees. Large quantities of chestnut have been planted in the New England states, and several parties have been induced to establish catalpa plantations in Kansas. The President of the society is Hon. J. Sterling Morton, of Nebraska City, Neb., late Secretary of Agriculture; Vice-President, C. A. Schenck, of Biltmore, N. C.; Secretary and Treasurer John P. Brown, Connersville, Ind.

TREE PLANTING is to be carried out this spring by the Illinois Central R. R., which will plant 110,000 catalpa trees at Harahan, La., 7 miles from New Orleans. The company owns a strip of land about ½ mile wide and 7 miles long between the Mississippi River and Lake Pontchartrain, which is crossed by the two lines of the railway system about three miles from the river. Between the railway and the river are the new freight terminal yards, and the plantation will be on the land between the railway and the lake. This work will be under the direction of Mr. W. J. Harahan, Chief Engineer. The catapla (catalpa speciosa) has been selected on account of its quick growth and the variety of purposes for which it may be used. The ordinary growth is about 1 in. annually in diameter, but in the rich soil and the long summers of Louisiana, the growth is almost double this amount and trees grown from seedlings planted in 1890 are now 20 to 25 ins. diameter. The trees are to be planted 8 ft. apart, and in a few years will be thinned out to 16 ft. apart, the trees cut down being then suitable for fence posts. The Boston & Maine R. R. has purchased 10,000 catalpas and will plant them this spring on unproductive vacant lands owned by the company, with a view to obtaining timber for poles, posts, ties and other purposes. Chestnut and black walnut will also be planted. Mr. Lowville Curtis, Roadmaster, will be in charge of this work. Mr. John P. Brown, of Connersville, Ind., Secretary of the International Society of Arboriculture, has been largely instrumental in interesting these and other railways in the subject of planting trees to obtain a timber supply and to make some use of vacant lands.

A CHANGE OF GAGE has been made on the Hancock & Calumet R. R., in the Michigan Peninsula, the gage being changed from 3 ft. to 4 ft. 8½ ins. The road is 26 miles long, and is owned by the Duluth, South Shore & Atlantic Ry. The work was completed in November, 1901. In contemplation of this change, the engineering department has during the past four years entirely equipped the track with 8-ft. ties. The work of changing was very simple, as all of the track was relaid with new 80-lb. steel rails. The ties were adzed level and the new rails laid outside of the old 50-lb. rails, except where frogs and switches interfered. At these points accurate measurements were taken, and the material left on the ground ready to complete the gap. When ready to change the gage, sufficient gangs were distributed to make all the changes that were left to make, in one day. This was on Sunday, and as this is an ore-carrying road and has no regular Sunday traffic, the work was done without interfering with the schedule time of a single train. Before starting on Saturday night all the narrow gage equipment was run to a storage yard which had been previously prepared, and the standard gage equipment was distributed over the line from both Hancock and Calumet as soon as the standard gage tracks were connected up. The roadmaster did the work with his own men. The standard gage line has been equipped with new 100-ton road engines, and also very heavy standard switch engines for work about the mines. No part of the old narrow gage equipment will be converted for use, but it will all be sold. For the above information we are indebted to Mr. H. J. Payne, Chief Engineer of the Duluth, South Shore & Atlantic Ry., Marquette, Mich.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a derailment on the New York, Chicago & St. Louis R. R., near Knox, Ind., on March 14. A westbound passenger train ran into an open switch, and was completely wrecked. Although many were hurt, no one was killed; four persons received dangerous injuries.

ELECTRIC LOCKING FOR SWITCHES is being applied by the Union Pacific Ry. at the ends of double track sections, in order to prevent accidents due to the careless use of the switches. Distant signals and track circuits are used, and after a train has passed the distant signal the switch cannot be opened until the train has cleared the junction of the two tracks.

THE LEAKS IN THE WHITING ST. RESERVOIR Dam at Holyoke, Mass., reported in the newspapers a few weeks ago, had been entirely stopped by March 11, according to a letter received by this journal from Mr. Jas. L. Tighe, City Engineer of Holyoke. The leaks appeared at the base of the masonry dam, where it rested upon earth, instead of rock. The dam was described in our issue of Sept. 6, 1899. It has a length of 1,773 ft., measured on the coping; a maximum height of 21 ft. above the natural surface of the ground. For 1,000 ft. of its length the dam rests on "a very compact and unyielding gravelly hardpan," to quote from the article mentioned above. The rest of the dam rested on rock, into which "benches were cut, deepest on the water side." Where the dam rested on the earth a trench 5 ft. deep and 16½ ft. wide was dug and a foundation of those dimensions built. In the center of this trench 3-in. matched sheet piling was set in a trench 5 ft. deep (below the masonry) and filled about with good puddle." The sheeting extended 1 ft. up into the masonry and the structure was made "water tight there by grouting the masonry." Above the foundation just described the dam was 15 ft. wide at the base, 10 ft. wide 15 ft. above that level, and 7 ft. wide at the top. The water level was 2½ ft. below the top of the dam, giving a depth of 18½ ft., but where the leaks appeared the head of water was not over 6 or 7 ft, and there was, as we understand it, several feet of earth filling against the inner side of the dam. The leaks were not great, but extended over a distance of 400 ft. They were attributed to the pressure of ice on the dam, the cutting of which had been overlooked. The leaks decreased as soon as the ice was cut and "practically disappeared" after the water side of the dam had been backed with gravel. We are indebted to Mr. Tighe for the information regarding the leaks and the measures taken to stop them.

THE AWARD OF THE PITTSBURG WATER FILTRATION contract has been enjoined by the U. S. Circuit Court on the ground that no estimate of the total cost of the work has been made. The city charter very specifically provides that no contracts for portions of a public improvement shall be awarded until estimates of the total cost have been made.

A WATER SOFTENING PLANT is to be built for the Tennessee Coal, Iron & Railroad Co., at Ensley, Ala. A gravity supply main will lead to the softening plant and from the latter to the boilers at the mines, blast furnaces and steel works of the company. There will be four 30 × 30-ft. precipitation tanks, with cone-shaped bottoms to facilitate removing the sludge; and two steel filters, 20 ft. in diameter and 8 ft. high. The contract for the plant has recently been awarded to the Pittsburg Filter Mfg. Co., Empire Building, Pittsburg, Pa.

SUITS FOR ELECTROLYSIS OF WATER MAINS are proposed by the water board of St. Paul, Minn. The board has had several recent conferences with the Twin City Rapid Transit Co., and began calling the attention of the company to alleged dangers from electrolysis some three years ago. Mr. Oscar Claussen is city engineer of St. Paul and Mr. John Caulfield is Secretary of the Water Board.

THE BELLEVILLE WATER-TUBE BOILERS in the Lake steamers "Northwest" and "Northland" are being replaced with Scotch boilers. The Belleville boilers were installed when the vessels were built a half dozen years ago. It is said the boilers were not able to furnish steam to give the vessels the speed which they were originally designed to make.

A TURBINE YACHT has been ordered by Mr. A. L. Barbour, of New York, from Messrs. Ramage & Ferguson, of Leith. Mr. Rufus Fleming, U. S. Consul at Edinburgh, describes the yacht as designed by Messrs. Cox & King, naval architects, of London. It will be 252 ft. 3 ins. long on the water line, and 300 ft. over all, 32 ft. 6 ins. beam, with a molded depth of 21 ft. The yacht will have 2,500 I. HP., with engines, etc., not materially different from those built for the "King Edward," with three propellers. The speed expected is not stated, other than " it will not be less than 16 knots."

CONCRETE-STEEL BRIDGE ACROSS KENDUSKEAG STREAM, AT BANGOR, MAINE.

We illustrate in the accompanying cuts a concrete-steel bridge recently built at Bangor, Me., which is of interest for being the first bridge in the eastern states to be built on the Ransome system, and also because the arches are perched high on existing abutments designed for vertical reactions, but not to resist arch thrust.

FIG. 1. CONCRETE AND COLD-TWISTED STEEL ARCH BRIDGE ACROSS KENDUSKEAG STREAM, AT FRANKLIN ST., BANGOR, MAINE.
The Aberthaw Construction Co., Boston, Mass., Designers and Builders.

The description of the bridge which follows has been furnished us by the Aberthaw Construction Co., of Boston, Mass., which owns the Ransome concrete cold-twisted steel construction patents in the New England States, and which designed the bridge and had the contract for the work. As a preface to this description it may be noted that the bulky center pier, shown in Fig. 1, was built by the United States Government some years ago and is about 200 yards long, crossing three streets. It is constructed of two parallel walls closed at the ends by the wedge-shaped cutwaters shown, and filled between with earth. The shore abutments were built by the city of Bangor in 1900. The bridge is located on the line of Franklin St. The description sent us by the contractors is as follows:

This bridge was placed on existing granite abutments, 26 ft. high, 12 ft. thick at the bottom, and 3½ ft. thick at the top. The facing was of first-class masonry. Triangular notches were cut for skewbacks, 14 ft. above the footings for the long span, and 15 ft. above the footings for the short span. In a number of places this cutting passed through the face course and showed the backing to be very poorly laid. The abutments, however, were not reinforced. A sewer outlet 4 ft. square empties through the two outside abutments into the stream. Its top is a little above the springing line of arch. A 10-in. gas main crosses the stream at such a level as to pass through each arch in two places.

The tide rises and falls about 10 ft. at the site of the bridge and log drives go up stream on the flood tide to a large sawmill, and sawed lumber comes down in scows on the ebb tide. The arch centers, therefore, were so designed as to leave the stream open to navigation. Arch ribs were made of three 2 × 12-in. plank spiked together. These were trussed several feet above high tide and were supported by posts resting on the abutment and against the wall; and also by inclined posts resting on the footing and reaching out at the top about 6 ft. from the abutment walls.

The ¾-in. square cold-twisted steel bars (Ransome system) ran, as shown in Fig. 2, in pairs 2 ins. from the extrados and intrados of the arch to the center of the bar, and 14 ins. on centers across the width of the arch. Their ends were free. A number of ½-in. bars were partly embedded in one day's work and projected into the next day's, thus tying the arch together crosswise and making it a monolithic vault.

The concrete was placed continuously from each skewback until the arch was closed at the center. Short ½-in. bars were imbedded radially in the arch in such a position as to tie to arch the 8-in. wall built on each face, and the 6-in. wall under each curbstone. The latter walls were reinforced with twisted steel and with buttresses 8 ft. apart. Self-supporting granolithic sidewalks were built over the area between the walls. This was done to relieve the abutments of as much dead load as possible. The roadway was filled with earth and paved with granite blocks laid on a 6-in. concrete base, and having their joints grouted with cement mortar. Holes 8 ins. deep were cored in the coping to receive the posts of the railing, which were grouted in position with Portland cement.

The dimensions of the small arch are: Span, 38 ft. 2 ins.; rise, 7 ft. 6 ins.; keystone, 10 ins. Those of the large arch are: Span, 46 ft. 7¾ ins.; rise, 8 ft. 7 ins.; keystone, 11 ins. and springer, 30 ins. The width of both arches is 40 ft.

The mixture of concrete used in the arch was 1 part Lehigh Portland cement, 2 parts sand, and 4 parts gravel screenings of all sizes from 2½ ins. to pea. The walls and sidewalks were of 1:3:6 concrete of the same materials. The soffit and face of the arch, the coping and the sidewalks had granolithic finish. The walls were dressed with picked face. There was no measurable deflection of the centers when the concrete was placed, or of the arches when the centers were drawn; or when the large arch was tested with 50 tons in the form of a road roller and teams loaded with granite blocks. There was no vibration of the bubble in a transit level when heavy teams traversed across the bridge. The street was closed to travel 16 days.

FIG. 2. VIEW OF FRANKLIN ST. BRIDGE AT BANGOR, MAINE, SHOWING MANNER OF PLACING TWISTED STEEL RODS READY FOR THE CONCRETE FILLING.

FOUNDRY ECONOMY.*

By Dr. Richard Moldenke.†

The rapidity with which the buying of pig iron on chemical specification, has spread among the foundries of this country, is perhaps the best evidence of the value of a rational method of procedure. Where at first the broker declined to sell iron under this arrangement or exacted an extra 50 cts. per ton, to-day the makers of foundry pig iron are almost altogether relieved from the annoying "Fracture Correspondence." That this revolution in practice has been no easy thing to accomplish may readily be imagined, and even to-day the majority of founders feel a little shy of irons with the proper composition which do not show the accustomed fracture.

With the selling prices of castings finding lower levels in every period of depression, the founder naturally asks himself: "How will I keep my margin of profit unchanged? I have been as economical as possible in every way, and yet other founders, whose tonnage is no larger, are quoting lower figures and seem to be making money. The solution is not so simple, and will be found based on a good cost system in the office and scientific method applied where needed in the shop. Just how the foundryman is to go about this work will form the sub tance of this paper.

Were it simply the question of employing an expert, the foundry doing a large business would soon be going in the right direction; but experts who have been through the changes of the last decade, and know what is wanted, are scarce. Technical graduates and others who can carry out the scientific manipulations required in a laboratory must be given a few years to acquire practical foundry experience before they become valuable. The owner of a small foundry, therefore, finds it difficult to take advantage of those economies which great institutions have developed after years of pioneer work in their respective lines. The founder must do a little studying himself, of cause and effect in his foundry. He must so systematize his operations that should he not have a metallurgist on his staff, he need call in one only on occasion of troubles which require quick adjustment.

The molding machine question will be found the most important one so far as the foundry pay roll is concerned. A well-managed pattern shop and pattern storage system are also money savers.

The iron itself will naturally give the founder food for continuous thought, as it is a constantly changing factor.

*From the "Journal of the American Foundrymen's Association" for April.

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To effect the greatest saving in the cupola room, one must know what is there, what to buy, and how the material is handled. Take first the pig irons. They will either be piled by car loads, or stacked together by brands and with stock numbers. Thus we will see a separate pile for Low Moor No. 2 soft, Sloss No. 2 plain, Isabella No. IX, Pioneer No. 4, and the Softeners.

They are still separated by brands as formerly, this serving the purpose of locating any undesirable qualities shown in castings of an otherwise satisfactory composition. This statement requires further explanation. It is well known in the foundry trade that some irons are stronger than others, even where an analysis shows them to be of an identical chemical composition. This difference is most noticeable in irons of the lower silicon ranges, and in the case of charcoal and coke irons of the same cross-section. Among the charcoal irons we find that a cold-blast metal is stronger than one made with warm blast, even if the former has more impurities. I have always contended that this lay in the manner of running the blast furnace, in so far as it affects the oxidation of the resulting pig iron. A furnace which charges pure stock and runs normal should make strong iron. The forcing of the operation, however, coupled with the addition of quantities of mill cinder and salamanders of burnt iron which can have no chance for proper reduction before they are melted and in the bottom, can only yield an inferior product for remelting in the foundry, no matter how valuable it may be in the making of open-hearth steel.

The piles are now arranged according to their silicon contents, due regard being paid to the other constituents as a matter of course. Thus, in the jobbing foundry, with sulphur and phosphorus normal in a given line of shipments, there would be one pile for 1.75% silicon, one for 2%, another for 2.25%, and finally one for 2.50%, or four piles. If there were three brands kept in stock in all the varieties, the number of piles would be twelve. If experience indicated poor results with the low silicon ranges of any particular iron, these would be omitted in making the next contract. For light work there would be extra piles for 2.75%, 3%, and even 3.25% silicon, and special piles also for high phosphorus metals. Occasional bargains in high sulphur pig irons suitable for floor plates would also come in for this method of piling.

A letter of the alphabet painted conspicuously on each pile, and a stock book for continuous record will give the foundry superintendent the information wanted at a glance when making out his requisitions. This also conceals the identity of the iron so far as unauthorized persons are concerned, all the more so if the letters are changed about as the piles run out. The ferrosilicons and silico-spiegels being only used in small quantities, and that only in emergencies, usually find a convenient resting place a little out of the way of the stock irons.

The scrap heap will form the next consideration. Two general classes must be reckoned with. That which we make and that which we buy or take in exchange for good castings. As will be shown later, it is necessary for the founder to know almost daily how his product is coming out, in order that he may keep his mixtures in proper shape. This information, consisting practically only of the silicon and occasionally the sulphur in the castings made, also answers for the domestic scrap. It is also possible to keep the low phosphorus scrap for low phosphorus mixtures.

With the bought, or as we call it, "foreign" scrap, things are a little different. As it is manifestly impossible to attempt a reliable sampling of this material in order to find out what it contains, we must do a little guessing on this point, and then use no more than the mixture can safely stand without upsetting our calculations. Fortunately certain lines of castings require irons of a pretty generally understood composition. A piece of stove-plate scrap, whether of recent date, or made 50 years ago, may be safely counted on as containing 2.75% silicon, and 1% phosphorus. Ordinary machinery scrap is never far from 2% silicon, with phosphorus and sulphur normal. Heavy machinery may be classed as 1.75% silicon, and if it should contain more, so much the better. Scrap rolls, plates, car wheels, malleable scrap; in fact, everything out of the ordinary line of foundry work should not be used in quantity unless an expert is at hand to see that it is properly cared for in the mixture.

The founder, then, who wishes to make up his mixtures from day to day by more accurate methods than the cut and try, will first settle upon the proportion of pig iron and scrap the necessities of the case compel him to use. He must take care of his own scrap in the first instance, and then look over the market prices of pig iron and scrap for the rest of his mixture; always remembering that the class of work he makes must not be injured by too great a cheapening of his melt. Cases may occur in which no foreign scrap is admissible at all, and your own, and a lot of steel in addition will only just let you out on the specifications. Unless you are running a sash-weight factory, 60% of scrap, your own included, is about all you can safely stand. 25 to 40% is a good average.

It was once my misfortune, through delays in shipment, to be left without any pig iron of the kinds I could use, in the yard for the period of four days, and 50 tons of castings had to be delivered daily under contract. A mixture consisting of 97% scrap, most of it foreign, and 3% silico-spiegel, containing 24% manganese and 18% silicon, answered all the requirements of the case, and nearly cleaned out the scrap pile. This is quoted not as an example to follow, but merely to show that a little science was a handy thing around the foundry just then.

For the purposes of the mixture calculation, suppose you prefer 70% of pig iron, 15% of your own scrap, and 15% of foreign scrap. The size of the charge which experience has shown to be the most economical with your cupola is 5,000 lbs. You may use five charges one day and seven another. Of this 5,000 lbs. 3,500 will be pig iron, 750 lbs. your own scrap, and 750 lbs. foreign scrap. Experience has further taught you that the class of castings you make should average 2.10% in silicon. This means 2.35% in the mixture, as about 0.25% is burned out. Your scrap running 2.10% silicon, and the foreign 2% we have the following:

Domestic scrap.....	750 lbs.
Silicon 2.10% gives total silicon.....	15.7 "
Foreign scrap	750 "
Silicon 2% gives total silicon.....	15.0 "

Or 30.7 lbs. of silicon of the 5,000 times 2.35%, or 117.5 lbs. silicon wanted in the charge. This leaves 86.8 lbs. to be furnished by the 3,500 lbs. of the pig iron to be used. Now, in buying pig iron, it is always best to get the stock so proportioned that the greatest quantity on hand is that used to counterbalance the scrap put in. In the case under discussion, which is really that of the ordinary jobbing foundry, irons running 2.50% in silicon are the ones required in greatest quantity, only smaller stocks of 2%, 2.25%, and 2.75% being necessary. Let us therefore take 2,000 lbs. of say "Sloss" with 2.50% silicon. This means 50 lbs. of the 86.8 accounted for. 1,500 lbs. must now furnish the remaining 36.8 lbs. silicon, or the iron would have to run 2.40% silicon. As we do not have this in the yard, we can either reduce the Sloss a little and make up with iron running 2.75% from the stock, or we may split up the remaining 1,500 lbs. into 1,000 lbs. at 2.75%, and 500 lbs. at 2.25% silicon from the yard. Doing the latter, as it gives us three brands of iron in the mixture instead of two, we have:

	Lbs.			Lbs.	
Domestic scrap.	750	at 2.10%	silicon, gives	15.7	silicon.
Foreign scrap..	750	" 2.00%	" "	15.0	"
Sloss.....	2,000	" 2.50%	" "	50.0	"
Low Moor.....	1,000	" 2.75%	" "	27.5	"
Mabel.....	500	" 2.25%	" "	6.2	"
	5,000	"	with	114.4	"

The mixture would therefore have 2.28%, which is near enough to 2.35% to pass. It is probably the simplest way to get it out. You can calculate it in your office in a few minutes, and be certain that the castings will come out right, if the mixture is properly handled and your materials are good.

Now, what is needed to make this work on mixture making successful? Simply a knowledge of what is in your pig iron, and what is in your own scrap. Even this can be narrowed down to the silicon in both items for the daily run of work. I will go even further and say that two or three determinations of silicon a week, together with stocks of iron, well sampled and analyzed as they are bought, and an occasional sulphur determination of your coke, is all that the jobbing or stove founder requires. I know cases where this work amounts to less than $6 a week, or not even the wages of a laborer. I feel quite certain that many a young chemist would be glad to locate in a foundry center if he can get that much from three or four foundries to begin with.

The above is naturally based upon the supposition that you, your sons, or your managers will do the thinking, the chemist only the manual work. Where you have enough thinking to do in this line to afford a good man in your works, get him, and your foundry foreman will thank you for relieving him from the responsibility and sleepless nights occasioned him by the changing of irons.

I mentioned chemical specifications for pig iron several times. This is simple enough. We deal with silicon, sulphur, phosphorus, manganese and total carbon, important in the order named. The limits of these elements in foundry work are now generally known, and so we simply specify like this: For ordinary medium weight machinery castings, silicon 2.50%. This does not mean 2 to 3%, or even 2.25 to 2.75%, but nothing wider than 2.40 to 2.60% silicon. Make an agreement that everything between 2.25% and 2.40% takes the 2.25% price, and you will have no difficulty in getting what you want.

To resume—Manganese is specified to be not over 0.80% unless special reasons require an extension of this limit. Similarly phosphorus not over 0.80%. Sulphur should not exceed 0.05%, and if very soft castings are wanted total carbon may be required not under 3.75%.

With the purchase of pig iron under chemical specifications, a good method of making mixtures which can be depended upon to produce the results desired, and the proper disposition of the charges in the cupola, the good that science can do the founder is accomplished in the main. There are of course many points which a well-managed laboratory can place on an economical footing, especially when we turn to furnace irons, and special lines of castings. For the owner of a foundry which turns out say ten tons of castings every other day, it would, however, be unwise to establish this department as an adjunct to his works. He does better by sending his work out and learns all he can to properly apply the reports he gets.

NOTES ON THE CONSTRUCTION AND OPERATION OF COOLING TOWERS.

By J. R. Bibbins,* B. S.

There have recently appeared, in the technical press, descriptions of new forms of cooling towers for cooling circulating water in steam power plants using condensers. Some of these new forms present innovations in design from which excellent results are said to be secured.

In view of the comparative absence of reliable data on the operation of cooling towers in general the following notes are submitted, including description and tests of an experimental tower recently put into service by the Edison Illuminating Co., of Detroit, at their generating station C.

Observations made during and subsequent to the test of this tower have resulted in certain opinions upon questions of design which are briefly set forth in the following.

DESIGN.

The essential points in the design of a tower may be discussed under the following heads:

1. Cooling Surface.
2. Draft.
3. Water Distribution.

1. COOLING SURFACE.—Upon the effectiveness of the cooling surface depends to a large extent the operative efficiency of the tower, other conditions remaining the same; the term efficiency being here used in the sense of thermal efficiency in the case of a natural draft tower, and thermal and mechanical efficiency combined in the case of a forced draft tower. In either case the abstraction of heat units is the desired effect, and may be considered as the output; this to be divided by the

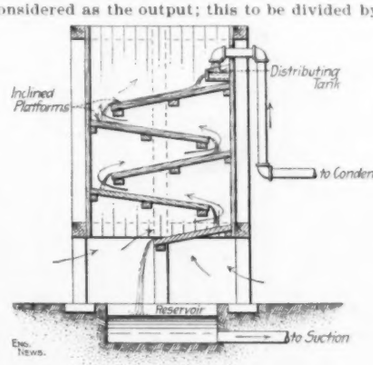


Fig. 1. Primitive Type of Cooling-Tower.

aggregate work expended in supplying the tower with water and air to obtain the efficiency.

In any cooling tower the process of temperature reduction is not effected by conduction alone; in fact, the heat which the circulating air abstracts by surface contact with the falling globules of water is by far the smaller part of the total cooling; the major portion of the heat absorbed disappears in the process of evaporation. In order to secure maximum evaporation the water must be thoroughly aerated, necessitating a surface construction which shall most effectively break up the descending streams and bring them repeatedly into intimate contact with the circulating air.

The development of an efficient cooling surface has been gradual, beginning with the employment of no surface at all, viz., a series of fine sprays directed into a settling pond of large area. In mining districts a series of inclined baffles of rough sawed lumber is commonly employed, as illustrated in Fig. 1, or simply a series of brush heaps, piled upon the several platforms of a rough wooden tower, the prevailing winds being depended upon to effect the required evaporation. A great improvement was made by substituting a vertical cooling surface of rough lumber, corrugated iron, wire netting, etc., as shown in Fig. 2, for the horizontal surface, both surfaces of the material being thus rendered equally active and the free passage of air greatly facilitated at the same time.

*56 Hastings St., Detroit, Mich.

The Worthington tower, Fig. 3, employs tile or galvanized iron pipes set on end in tiers, sheets of wire netting being interposed between successive tiers. While not, perhaps, as efficient as a continuous evaporating surface, like that of Fig. 2, yet this arrangement permits of extension upwards at any time for the purpose of increasing the capacity of the tower. This is accomplished by simply adding tiers of tubes and of outer shell and suitably extending the supply piping.

The surface used in the experimental tower, Fig. 4, is well illustrated in Fig. 5, which is a view looking downward into the tower, and showing the "mats" as placed in position. These mats are constructed of ordinary rough sawed lath assembled side by side upon a substantial backing strip, with short separators between. The efficiency of the surface thus obtained is obviously high, as it is entirely active and its roughness materially aids in obtaining maximum intermixture of air and water. Its chief defect is its non-continuity, but this is more properly a question of installation and not directly chargeable against the surface itself. The successive tiers of mats are rotated 30° from each other about the center post, as shown in Fig. 5, in order to prevent any portion of water falling freely a considerable distance; practically all water is forced in this way to flow for a greater part of the way over the evaporating surface.

One American manufacturer employs a construction similar to the above, except that the mats are placed horizontally, the directions of the lath in successive tiers crossing each other at right angles. The edges of the lath are beveled, for the purpose of decreasing the large resistance to draft. The absence of definite information upon the performance of the surface prevents comparisons, but the construction is entirely at variance with that of towers at present in successful operation, both in regard to continuity of surface and impedance to draft.

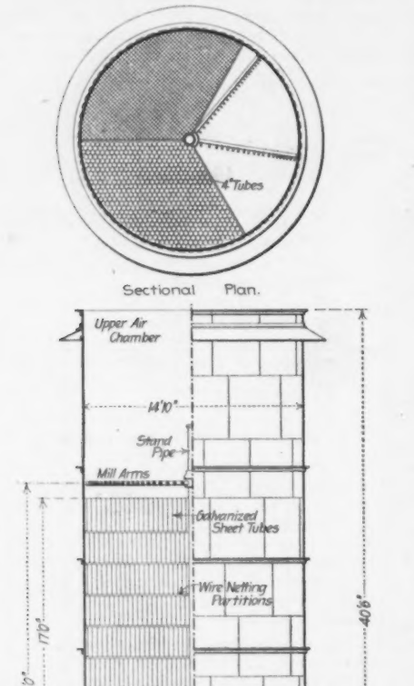


Fig. 3. Worthington Forced Draft Cooling-Tower.

The use of a metallic surface, whether in the form of netting (as in the Barnard), corrugated sheet, plain sheet, or pipe (as in the Worthington), is particularly advantageous for the reason that the shortcomings of the distribution system are

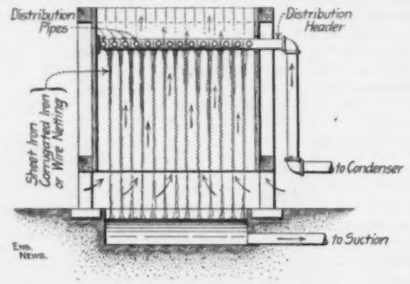


Fig. 2. Improved Type of Cooling-Tower.

corrected by the conducting power of the metal surface. A rapid interchange of heat takes place in the body of the metal which tends to compensate for non-uniform distribution, thus rendering active otherwise inactive surface.

2. DRAFT.—The effectiveness of operation of a cooling tower varies with changes in the circulation of the air:

(a) Directly with the velocity, within limits defined by conditions of complete (vapor) saturation of the air or an excess supply.

In a fan tower, if variable driving speed were available, and a curve were plotted with air velocities as abscissas and percents of gain in tower "duty" or capacity, as ordinates, the curve would show an initial uniform rise for a considerable period, then a gradual sloping over to the horizontal, which point of change of curvature would indicate excess supply of air, and consequently the economical limit of operation. This limit would vary with season, load and weather. In case the fan is driven by motor or auxiliary engine, it is obviously possible to effect a large saving in power consumption by varying the speed of the fan according to the load, as indicated by the excellence of the vacuum.

(b) Inversely with the temperature and the humidity of the atmosphere.

When operated as an auxiliary to an electric lighting station, a cooling tower is to a certain degree automatic in action, as regards the relation of its capacity to the load on the station. The latter is small in summer and large in winter; in hot weather the large degree of atmospheric saturation, together with the small temperature difference between atmosphere and pump delivery, permit of but comparatively small cooling effect, while in cold weather the absorption of heat by (1) conduction is greatly enhanced by low atmospheric temperature, and (2) evaporation, by relatively low humidity.

In designing, the greatest care should be taken to maintain a path for the moving air with the minimum number of obstructions and as direct as possible. Sharp turns, contracted areas, and especially directly falling water should be avoided as far as possible, the latter being, perhaps, the most fruitful cause of loss in present systems by reason of the "drag" occasioned by the falling globules, each of which carries with it a small atmosphere of saturated vapor, the resultant effect being a serious back pressure on the air-circulation system.

A comparison of Figs. 1 and 2 at once reveals the undesirable points of one and the excellent points of the other construction, viz.: in Fig. 1 the long sinuous passages, with their obstructions in the shape of timbers and falling sheets of water; in Fig. 2 the direct, vertical passages for the circulating air between the water sheets adhering to the sides of the cooling surface during descent.

The towers, Figs. 3 and 4, both of which are in operation at stations of the Edison Illuminating Co., of Detroit, illustrate two distinct types of tower as regards draft, viz., the natural draft type and the mechanical draft or fan type. Each type has its particular field for and conditions of operation. A parallel comparison of the two types is given herewith:

FAN.	NATURAL DRAFT.
SIZE.	
Small.—The forced draft providing sufficient air velocity to effect evaporation. Height limited as loss from back pressure increases as square of velocity of circulating air. Floor space unlimited. Tower usually short and of large area.	Large.—Draft necessarily small; large area must be provided to perform same work. Height advantageous, as tower operates as a chimney, and depends upon "air head" or difference in pressure for its circulation.
POWER CONSUMPTION.	
One per cent. and upwards, either as motor, auxiliary engine or belted.	None.
LOCATION.	
Inside or outside. Can operate in any location where sufficient head room and air supply is available. Especially adapted to inconvenient locations as roofs, upper deck, boiler floors, etc.	Outside only, unless exceptionally good draft is obtainable. Preferably in the open where advantage may be taken of prevailing winds and tower is free from reverse currents over buildings, etc.
CONDITIONS OF ATMOSPHERE	
Comparatively little affected by temperature, considerably by humidity, and none by winds.	Largely affected by temperature and humidity, draft increased by steady winds.

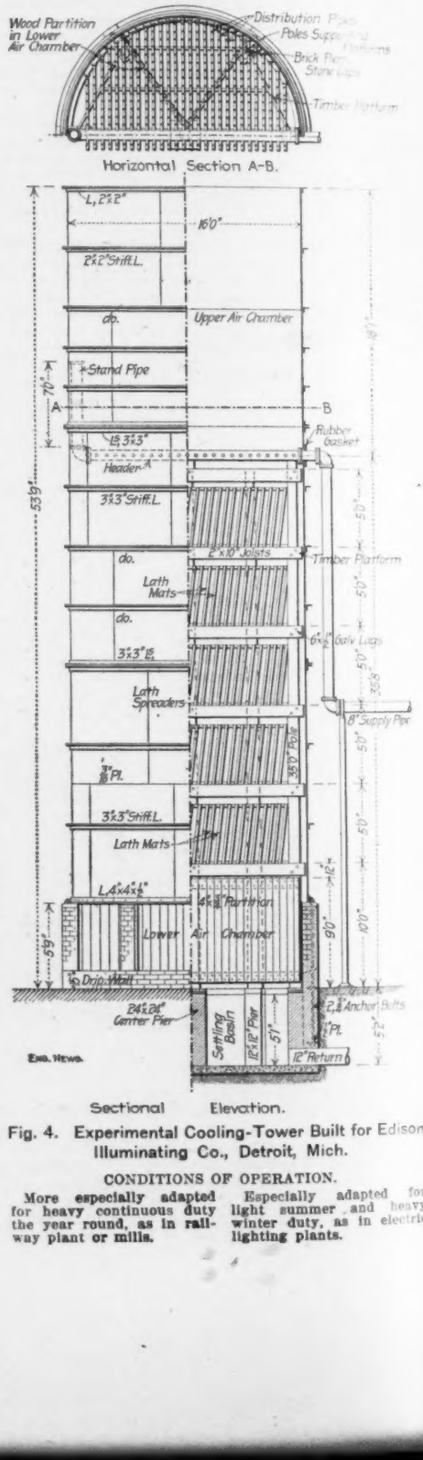


Fig. 4. Experimental Cooling-Tower Built for Edison Illuminating Co., Detroit, Mich.

CONDITIONS OF OPERATION.	
More especially adapted for heavy continuous duty the year round, as in railway plant or mills.	Especially adapted for light summer and heavy winter duty, as in electric lighting plants.

COST (PER HP. ULTIMATE CAPACITY).

Greater, on account of mechanical construction and necessary auxiliaries.	Smaller, by reason of simplicity of construction.
Cost of operating considerably reduced by using efficient auxiliaries, viz.: Motors, gas engines, belted to main shaft, but not small steam engine.	Cost largely dependent upon materials used in interior construction.

Approximate figures on the two towers Figs. 3 and 4 are appended:

	Type. Fan.	Nat. draft
Horse power	1,500	900
Cooling surface, sq. ft.	34,780	24,500
Surface per HP., sq. ft.	23.2	27.2
Space occupied, cu. ft.	7,064	10,850
Floor space, sq. ft.	175	200

Cost: First, per HP.—Fan $2.60; Natural draft, $1.50; Operation per year—Fan, 13.6 E. HP. × 24 hrs. per day = 119,000 HP. hrs. annually.

An important point in the consideration of draft is the provision of liberal air chambers at the

Fig. 5. View Looking Down into Tower.

bottom, and as much "stack" at the top as is necessary for proper circulation.

The lower air chamber should also be provided with diaphragms for the purpose of preventing transverse air currents through the base of the tower. Thus, in the tower shown in Fig. 4, the base is divided into six compartments by radial wood cross-partitions, which effectually check all cross-air currents and direct them upward to aid in the process of evaporation.

3. WATER DISTRIBUTION.—The immediate and important object of the distribution system is to deliver the hot condenser water as directly and uniformly as possible to the cooling surface, and to transfer it thereto with minimum agitation and splashing. The evil effects of directly falling water have been noted above, this being the main feature to avoid.

In the type of tower shown in Fig. 2 the desired effect is obtained by means of longitudinally-slotted pipes emptying directly onto the upper edges of suspended sheets, or else drilled so as to discharge sideways upon the sheet, the angle of incidence of the water being small to prevent splashing. The tower shown in Fig. 3 employs a Barker's mill mounted on ball bearings and fitted with straight radial arms, receiving their supply from a central standpipe, and drilled so as to discharge horizontally. The holes should here be of such size and so spaced that the velocity of the issuing jet should be slightly greater than the negative velocity of the orifice—a difficult problem in view of the pulsations of the pump, variable linear velocity of orifices, drop in pressure along arms and uncertain friction of the ball-bearing upon which the rotating system is supported. The distribution system of the tower, Fig. 4, is shown in perspective in Fig. 6, and is practically the same as in Fig. 2, with the exception that the jets are directed vertically upwards, the object being to reduce the jets to a spray before reaching the cooling surface, thereby maintaining more uniform distribution with this form of surface.

An important feature of any tower operated on reciprocating pump systems lies in the provision of liberal standpipe capacity (preferably at the last elbow in the main tower supply pipe, where this joins the distribution header), for the obvious purpose of providing an air cushion to absorb the violent impulses from the pump and redistribute the water with a more uniform flow. In installations where the tower is necessarily located at some distance from circulating pumps (e. g., on the roof), a consideration of the forces involved in periodically accelerating the large body of water contained in the pipe, points to the use of motor-driven rotary pumps for the circulating system in place of the usual duplex pump, and especially when the latter occurs as a mechanical unit with condenser and air pump. Independent operation of the air and circulation pumps is in this case particularly imperative, if more perfect vacuum control and minimum auxiliary power consumption is desired.

The remaining important feature of the water system is a settling basin of liberal depth wherein all entrained air may be allowed to separate and escape, thus preventing its final lodgment in the condenser and pumps.

DESCRIPTION OF TOWER, FIG. 4.

The drawing of the tower, with the views, Figs. 5 and 6, renders the construction so clear that but few comments are required.

The mats, made up as previously described, are shown installed in the same or parallel planes with the pipes. They may also be installed with each platform and set of mats set at an angular advance of 30° from that below or above, which arrangement gives greater lateral stiffness and rigidity to the wooden structure, and tends to prevent unequal distribution of air from below. The latter arrangement has been carried out in the tower, Fig. 4, with success. The entire weight of the piping is carried by the seven 35-ft. poles, which also support the five timber platforms of mats. The poles rest on stone-capped piers independent of the piers supporting the shell. In erecting, the foundation is bricked up to ground level, tower shell assembled and jacked up to required height to admit poles, poles inserted and braced, foundation bolts placed in yoke with stone caps, piers and drip wall bricked up to height, shell lowered to bearing on caps, and bolts tightened.

In case a self-supporting tower is required, the piers should be battered out to 24 ins. depth in order to give sufficient resistance to lateral displacement by wind pressure.

It will be noted in Fig. 6 that a number of the holes in the distribution pipes are plugged up. This expedient was resorted to for the purpose of correcting the uneven distribution of water due to excessive slant in the pipes, which should not exceed ½%.

TESTS OF TOWER.

Three tests have been recorded on the operation of this tower, two of them, however, being of a preliminary nature. The first, taken under the worst possible weather conditions (warm, precipitation), shows a cooling of 10—11° F. for a maximum load of 500 HP. In all three of the tests noted, only about 60% of the total cooling surface in the tower had been installed.

The results of test No. 3, taken on the last day of December, when the heaviest peak load of the year occurs, are recorded graphically in Fig. 8. The arrangement of the parts of the test apparatus will be readily understood from the diagram of connections, Fig. 7. The weather represented average early winter conditions, average temperature 31° F. The circulating water was estimated from the number of revolutions of pump, allowing a proportionate correction for the variation in stroke with cushion. The condensation was measured directly by the duplicate barrel method for the purpose of calculating the required cooling, as follows:

$$\text{Cooling (deg. Fahr.)} = \frac{\text{W't condensation} \times \text{latent heat at corresp. vacuum}}{\text{Weight circulating water.}}$$

The temperature of exhaust was not taken directly, owing to the absence of a suitable thermometer, and was determined from steam tables for the different degrees of vacuum.

Fig. 6. Water-Distributing Arrangement.

The pump discharge was purposely varied, and vacuum run low in order to observe the effects upon the tower. Diagram 1 shows an immediate increase of 6° cooling for an increase of 17 double strokes of the pump at 4.15 p. m.

The sudden drop in temperatures and condensation at 3.30 p. m. was due to an unexpected change of load on one of the substation tie-lines.

It will be noted that the maximum cooling occurs simultaneously with peak load of 670 K-W. net, or 950 gross HP. at 6.15 p. m., at which time the vacuum was allowed to fall to 17.2 ins., to the obvious detriment of the engineer's peace of mind, who could scarcely be restrained from "helping-out" the condenser with a spray of cold water.

The straight line, in Diagram 1, Fig. 8, gives the graphical characteristic of the natural draft cooling tower, and derives its slope entirely from the increased draft occasioned by the larger difference of temperature (and consequently greater air head) between inside and outside air.

It plainly indicates the entire dependence of the tower upon good draft for large operative capacity, and also shows that large cooling and poor vacuum are co-existent. This characteristic is ob-

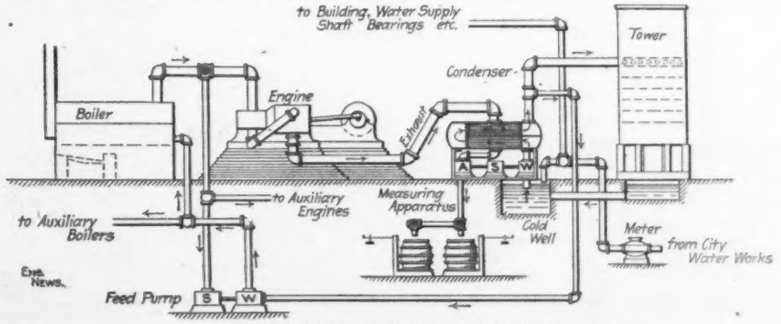


FIG. 7. DIAGRAM OF CONNECTIONS FOR TEST.

viously the lower portion of the curve above referred to under "Draft."

In this particular case the tower was, so to speak, overloaded, since, as previously mentioned, two-fifths of its mat surface still remained to be installed, leaving but 540 HP. to its credit against a load of 900 HP.

The broken line, on Diagram 1., Fig. 8, shows the cooling calculated by the formula given above. The discrepancy between curves A and B being constant, is undoubtedly due to amounts of air in the condenser vacuum chambers (which had found its way through the steam cycle from the boiler feed, in which it had existed in the occluded or dissolved state), thus altering the vapor tension.

The calculated curve serves, however, as a check on the observations, and proves a straight line to represent throughout its range the operation of the natural draft tower.

The parabolic curve at the bottom of Diagram 1. shows the amount of circulation water necessary

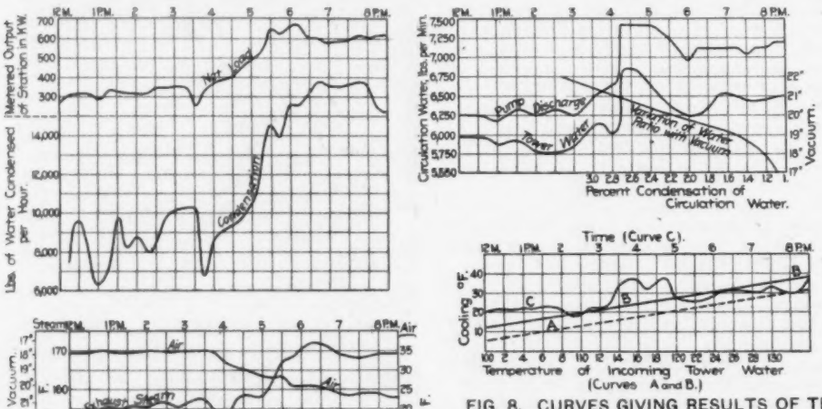


FIG. 8. CURVES GIVING RESULTS OF TEST ON EXPERIMENTAL TOWER AT STATION C OF EDISON ILLUMINATING CO., OF DETROIT, MICH.

Curves A and B; Relation of Cooling to Incoming Tower Water. Curve C: Time Log of Cooling.

for condensing purposes at varying degrees of vacuum, and indicates an approximately inverse ratio between temperature of exhaust steam and volume of circulating water.

The evaporation incident to the operation of a forced draft tower may be very great, especially under conditions of low atmospheric saturation. In the case of the Worthington tower, Fig. 3, the entire condensation from the station engines is turned into the tower circuit to supply evaporation losses. A recent test on the Edison tower, Fig. 4, with mat surface completely installed, shows an evaporation of 105% of the total condensation during a 24-hr. run.

SUMMARY.

1. Conduction plays a minor part in the process of temperature reduction; evaporation is the main agent.

2. Maximum evaporation is obtained by effecting as thorough and uniform water distribution as possible over the entire cooling surface.

3. Long sinuous passages, obstructions and falling water are incompatible with high draft effect. The more the descending sheets of water are retarded the better.

4. A settling basin of liberal capacity is essential.

5. Natural draft towers should be provided with extensive air chambers at top and bottom. These facilitate good draft by favoring good air distribution.

6. Reciprocating pumps require liberal standpipe capacity, located at the tee or elbow nearest the distribution system, unless the latter is of the open or trough type.

THE NEW FLOATING DRY DOCK FOR BERMUDA.

One of the largest floating dry-docks ever built was launched at the yards of C. S. Swan & Hunter, Ltd., at Wallsend-on-Tyne, on Feb. 8. It was built for the British Admiralty and is intended to replace the old floating dock which has been in service in Bermuda since 1869.

As described in "The Engineer," this new dock is 545 ft. long and 100 ft. wide between rubbing fenders. As it has no gates, the length of the ship lifted is not restricted. Up to the pontoon deck level its lifting power is 15,000 tons; but by utilizing the "shallow pound" this can be increased to 17,500 tons, and the walls are high enough to admit a vessel drawing 32 ft. to be taken on keel-blocks 3 ft. 6 ins. high.

The dock was designed to lift battleships of 15,000 ton displacement on a bearing length on keel of 343 ft.; but it is also capable of handling cruisers of the same tonnage and with 383 ft. of bearing keel, and auxiliary cruisers—like the "Campania," with 17,000 tons on a keel-length of 502 ft.

The dock itself consists of three main pontoons; the rectangular center pontoon is 300 ft. long, but the two terminal pontoons are each 120 ft. long, with 71 ft. of the center rectangular and the remainder finished off in a blunt bow. The sides of the rectangular portions of all the pontoons are built up to form a broad "altar" standing 12 ft. above the dock. The side-walls, on each side of the pontoons, are connected to the pontoons by double fish-plates and tapering pins fitting in steel lugs, so that the walls and pontoons may be disconnected for self-docking. These side-walls are rectangular; 435 ft. long by 53 ft. 3 ins. high. From the base up to the altar level the [illegible] is 13 ft. 2 ins.; but from there they batter [illegible] to 9 ft. 1 in., at the engine-deck. The ends of the side-walls are bevelled back to the same [illegible] as the pointed bows of the pontoons, to facilitate towing.

The pontoons are divided into 40 pump [illegible] divisions, of which 32 are absolutely water-[illegible] and distinct. The side-walls have each eight [illegible] tight divisions. Each of these divisions is provided with a separate pipe and separate [illegible] all of the pipes on the starboard half of the dock are led directly into the main drain in the starboard wall, and those on the other half into the port wall. These drains are continuous over the whole length of the wall, and the four 18-in. centrifugal pumps are seated directly upon them, and any one pump can empty its half of the dock. Thus the central bulkhead, dividing the dock into two halves, is not entirely water-tight; small drainage holes are left in it, and if one set of pumps broke down entirely, the other set would slowly empty the whole dock. Each pump has a separate condensing compound engine, with a separate return-tube marine boiler for each pair of engines. But the steam pipes are so arranged that either engine can take steam from either boiler, so that the system is practically duplicated in each wall. The whole dock is worked from a central position on the top of each tower.

To support the armor-belt of battleships, a stout channel runs along on top of the broad altars, into which the heels of vertical shores can be stepped; similar channels along the face of the altars receive the raking shores. The dock is equipped with strong bollards, six powerful vertical steam capstans, an electric light plant with its own generating machinery, and traveling and swinging electric cranes running the whole length of the walls.

As at low water, this dock may rest on the rough coral bottom of the harbor, the bottom of the pontoon is protected by bilge keels of greenheart. The decks are made of teak-wood.

While the Bermuda dry-dock is longer by 20 ft. than the U. S. Government floating dock, at Algiers, La., built by the Maryland Steel Co., at Sparrows Point, Md. (Engineering News, May 3, 1900), the American dock will lift 18,000 tons up to the pontoon level, and can raise 20,000 tons by utilizing the "pound." As compared on an equal basis, 33 tons of hull in the American dock will lift 100 tons of vessel, as against 39 tons of hull in the English dock to do the same work. The American dock hull weighs 5,850 tons, and the English dock hull 6,500 tons.

FRUIT HOUSES; CHICAGO, MILWAUKEE & ST. PAUL RY.

In the handling of fruit and vegetable traffic at railway terminals, particular care is required to maintain a uniform temperature so that the freight will not be spoiled, either by freezing or by rotting due to heat. In summer and winter this class of freight is very generally handled in refrigerator cars, but it is liable to be spoiled or damaged in being unloaded or transferred from such cars to wagons, or by being held in ordinary cars during hot or cold weather. Special fruit houses for the unloading, transferring and inspection of this class of freight are provided at many large distributing points, and the Chicago, Milwaukee & St. Paul Ry. has established special facilities at Milwaukee and Minneapolis, by erecting fruit houses in which the cars are placed, and in which a uniform temperature is maintained.

The fruit-house at Reed and Point Sts., in Mil-

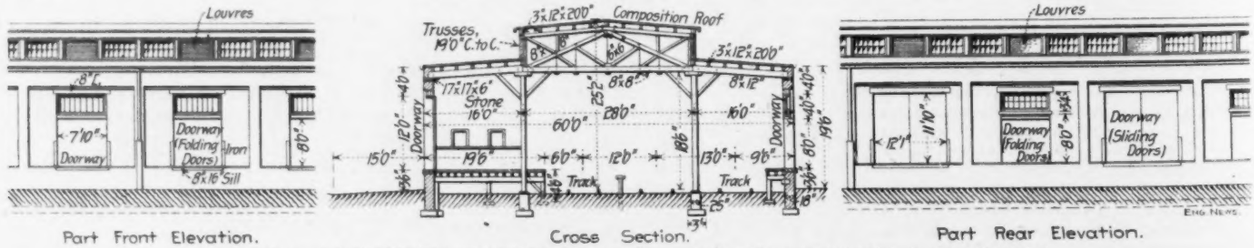
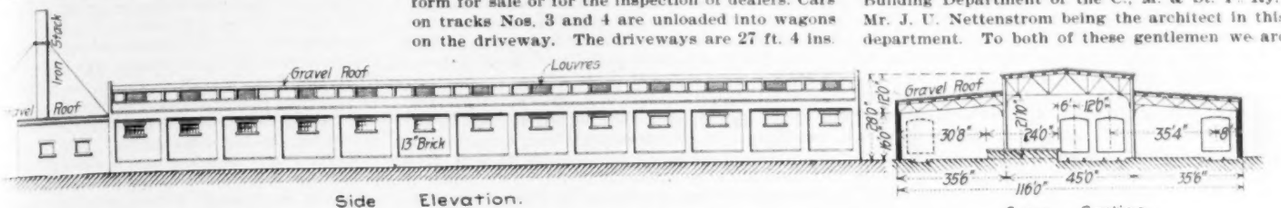
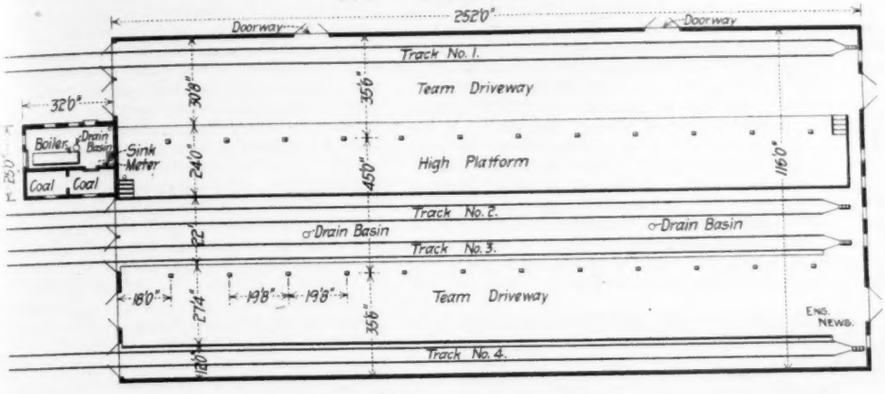


FIG. 3. FRUIT HOUSE AT MINNEAPOLIS, MINN.; CHICAGO, MILWAUKEE & ST. PAUL RY.

...ee, Wis., shown in Figs. 1 and 2, is 252 ft. ... and 116 ft. wide, built of Milwaukee yellow ... with wooden columns, steel roof trusses ... a gravel and composition roof. The clear ... inside is 16 ft. at the sides and 21 ft. under



Side Elevation. Cross Section.



Plan.

FIG. 1. FREIGHT HOUSE FOR FRUIT AND VEGETABLES AT MILWAUKEE, WIS.; CHICAGO, MILWAUKEE & ST. PAUL RY.

Chas. F. Loweth, M. Am. Soc. C. E., Engineer and Superintendent of Bridges and Buildings.

J. U. Nettenstrom, Architect.

the center span. The windows in the outer walls are above the level of the car roofs, and the principal light is afforded by the windows in the sides of the main span, which is some 6 ft. higher than the side spans. The windows are fixed, but between them are louvres. These are made with fixed slats, but on the inside are wooden shutters, hinged at the top and operated by cords, so that the ventilating space can be varied to suit the requirements. The center trusses, 45 ft. span, have vertical end plates bolted against the wooden columns. The side trusses, 35 ft. 6 ins. span, have their inner ends supported in the same way, while the outer ends are supported by piers in the brick

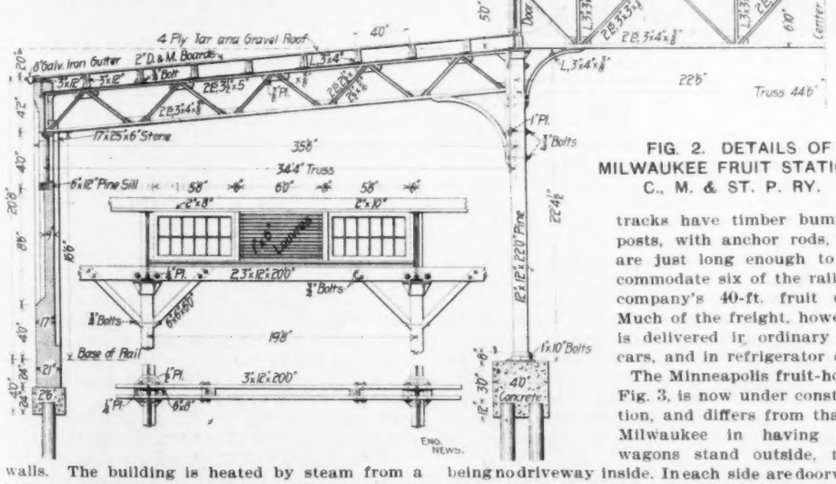


FIG. 2. DETAILS OF MILWAUKEE FRUIT STATION: C., M. & ST. P. RY.

walls. The building is heated by steam from a boiler in an annex. There are eight pipe-coil radiators against each wall, high above the floor, and two at each end. The temperature is kept at 50° to 60°F. Incandescent lamps are used, having long cords so that the lamps may be hung at the car doors or inside.

There are four tracks, two team driveways and a high platform. Cars on track No. 1 can be unloaded into wagons standing on the driveway, or through two side doors into wagons standing outside, the latter being used only in special cases. Track No. 2 is for cars having freight to be held (either in the car or on the platform) or to be transferred. Thus, if a dealer receives a carload of fruit and has an order for shipment, the fruit can be unloaded onto the platform, and the necessary amount reloaded into another car, without being carried to and from the dealer's warehouse; or it may be stored on the platform and the car released. Freight may also be exposed on the platform for sale or for the inspection of dealers. Cars on tracks Nos. 3 and 4 are unloaded into wagons on the driveway. The driveways are 27 ft. 4 ins. wide; that at track No. 1 is paved with gravel, while the other has a paving of rectangular wooden blocks. The surface is 6 ins. above the rail base. The platform is 24 ft. wide and 3 ft. 10 ins. high, with steps at each end. The doors are kept shut, except when cars or teams are passing in and out, and yard clerks and switchmen are required to see that car doors are properly fastened before the cars are run out of the house. The tracks have timber bumping posts, with anchor rods, and are just long enough to accommodate six of the railway company's 40-ft. fruit cars. Much of the freight, however, is delivered in ordinary box cars, and in refrigerator cars.

The Minneapolis fruit-house, Fig. 3, is now under construction, and differs from that at Milwaukee in having the wagons stand outside, there being no driveway inside. In each side are doorways 7 ft. 10 ins. wide and 8 ft. high, fitted with the Cross folding door, made of wood and folding vertically. These are made by the Variety Mfg. Co., of Chicago, Ill. On one side of the house, however, the alternate doorways are 12 ft. wide and 11 ft. 10 ins. high, fitted with sliding doors. There are three tracks in the building, and a platform along each side. One platform is only about 5 ft. wide, and is for unloading direct from cars to wagons backed up against the doorways. The other is 19 ft. 6 ins. wide, and is for freight, which has to be held or stored. Cars on the middle track are reached by passing through the cars next the platform. This building is 288 ft. long and 60 ft. wide, with brick walls and wooden posts and roof trusses. The general design is similar to that of the Milwaukee house.

The buildings were designed under the direction of Mr. Charles F. Loweth, M. Am. Soc. C. E., Engineer and Superintendent of the Bridge and Building Department of the C., M. & St. P. Ry.; Mr. J. U. Nettenstrom being the architect in this department. To both of these gentlemen we are indebted for plans and information. The heating equipment was designed by the motive power department. The masonry was built by Roberts & Co., at Milwaukee, and by the railway company's men at Minneapolis. The construction was done by the Bridge and Building Department, the railway making it a practice to do a large amount of construction work of this kind by its own force, rather than by contract. The cost of the buildings complete, including heating plant, etc., was about $25,000 for the one at Milwaukee, and $15,000 for that at Minneapolis.

THE NEW FERRY BRIDGE ACROSS THE SHIP CANAL AT DULUTH, MINN.

By W. B. Patton.*

(With two-page plate.)

Minnesota Point, the natural breakwater which separates the waters of Lake Superior from the harbor of Duluth, extends in a general south-southeasterly direction, with a width of from 300 to 800 ft., for a distance of 6.6 miles from the Minnesota shore. At its outer end it is separated from Wisconsin Point by the "natural entry," through which formerly flowed all the waters of the St. Louis and Nemadji rivers; and which was the only means of access to the harbor.

The city of Duluth was originally laid out on the northerly half of Minnesota Point, but this location was soon abandoned for the mainland, about the base of the point. As no deep water channel in the harbor connected the natural entry with the new city, an effort was made to establish an artificial harbor in the lake. This harbor was found to be inadequate and unsatisfactory, and in the fall of 1870 the city began the excavation of a ship canal across Minnesota Point, about half a mile from the mainland. The work was completed by the winter of 1871, although strong opposition was encountered, and many obstacles had to be overcome. This canal was 250 ft. in width, except at the lake end, and was provided with piers of timber cribs.

The six miles of Minnesota Point thus severed from the mainland, although it had ceased to be a part of the city proper, still continued to be a place of residence for a small population, which traveled across the canal, during the open season, in row boats, and during the closed season on the ice, or, for a number of years, on an improvised suspension foot bridge, to cross which required more than ordinary courage.

The city of Duluth has, ever since the cutting of the canal, looked with regret at the large amount of its most valuable dock frontage—the bay side of the point—which it is impossible to use on account of lack of means of access for railroads and teams: and for years efforts have been made to devise practical means of transportation across the canal, which would provide for the business development of the property on the "Point," and for the convenience of its residents, and the

*City Engineer, Duluth, Minn.

rapidly increasing number of the people of Duluth who are using its beautiful wooded grounds for summer camping and picnicing.

The conditions to be met in a successful solution of this problem are most difficult. The canal points directly into the teeth of the prevailing and most severe storms of the locality, and, consequently, vessels using it must have an absolutely unimpeded passageway. A central pier is an impossibility, and any structure designed to move across the canal must have a certainty of action approaching the perfect. It must also be under complete control at all times, and capable of being employed at very irregular intervals, owing to the large number of vessels arriving and departing, 8,309 vessels, besides tugs and small craft, carrying 6,851,729 tons of freight and 88,833 passengers, having passed in and out during the season of 1901. Any design for permanently spanning the canal must leave a clear head-room of 135 ft. above high water, as masts 120 ft. high are carried by some of the vessels.

The first attempt to provide a permanent crossing was made in 1890, when the services of Mr. A. P. Boller, M. Am. Soc. C. E., were secured to prepare plans for a bridge. His report was submitted in March, 1890, and recommended a drawbridge, with the pivot pier on the south side of the canal, and with a clear span of 200 ft. between fenders, the clearance above high water being 20 ft. The estimated cost of this plan complete, exclusive of right of way and damages, was $400,000. These plans were approved by the city, and bids were asked for and received for constructing the substructure, but owing to strenuous opposition which developed the project was abandoned.

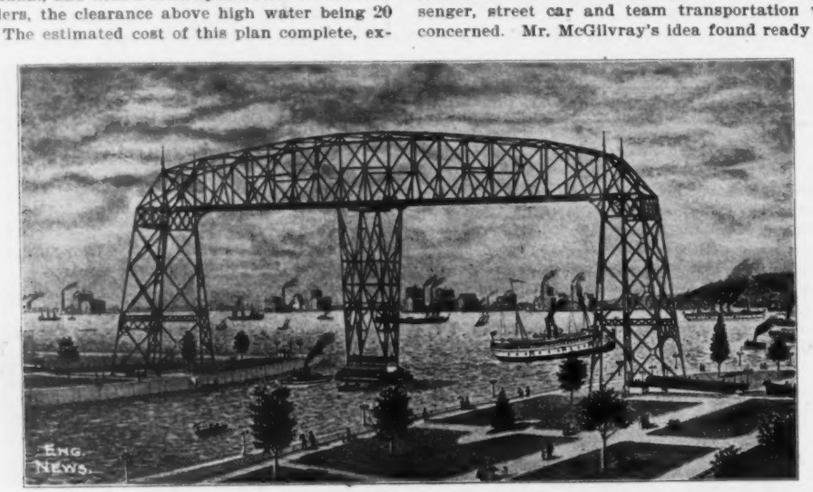


FIG. 2. VIEW OF FERRY BRIDGE ACROSS THE SHIP CANAL AT DULUTH, MINN.

The next proposal was for a tunnel, and at the request of the city Mr. Wm. Sooy Smith, M. Am. Soc. C. E., prepared plans and estimates for such a structure. Several methods of construction and different capacities for a tunnel were presented, with estimated costs of from $881,697 to $1,338,359, without pavements or land damages. The large cost of this scheme made it impossible for the city to undertake it, although its merits were unquestionable; and recourse was had again to some form of bridge.

In November, 1891, a prize of $1,000 was offered for the best design for a drawbridge. Twenty plans were submitted (Eng. News, Oct. 27, 1892), and the prize was awarded to Arnetz & Sangdahl, of Milwaukee, Wis., for a bridge with the pivot pier on the south side of the canal and with a clear span of 250 ft., the estimated cost being from $236,000 to $350,000. At the same competition J. A. L. Waddell, M. Am. Soc. C. E., submitted plans for a lift bridge, at an estimated cost of $150,000, which, although not in accordance with the advertisement, and which consequently could not be considered in the award, was regarded by the city to be the best adapted to the location; but on submitting the matter to the U. S. Government, which had taken control of the canal, the Board of Engineers appointed to consider the request of the city for permission to erect the bridge, refused to approve and decided against any form of bridge in this location.

It was now clear that all attempts to secure railroad service across the canal must be abandoned, and the efforts of the city were directed to providing for the convenience of the people who must pass to and fro. A free rowboat ferry was established, which in 1898 gave place to a free steam ferry, which costs the city $9,000 per annum for operation. The cost of this service and its unsatisfactory nature has kept alive the agitation and desire for something better, but in the meantime the difficulties had been increased by the fact that the U. S. Government had condemned the property and streets on both sides of the canal and had widened it at Lake Ave. to 322 ft., with concrete piers on each side, thus making necessary a span of over 390 ft. for any form of bridge erected at this location.

In the fall of 1899 the attention of the then City Engineer, Mr. Thos. F. McGilvray, was directed to the ferry bridge constructed by M. Arnodin at Rouen, France, and he immediately noted the applicability of such a structure to the local conditions at the canal. Preliminary sketches for a suspension bridge of the general type of that at Rouen were prepared by him, and the consideration of the city government was called to it as a possible solution of the problem, so far as passenger, street car and team transportation was concerned. Mr. McGilvray's idea found ready acceptance, and steps were taken at once to overcome the many difficulties in the way; for in addition to the former obstacles the city could not finance the bridge without special legislation, and, further, the permission of the U. S. Government had to be obtained, not only to erect and maintain the bridge over the canal, but to occupy government property with the piers.

The special legislation was secured, and assurances as to the overcoming of the other obstacles were obtained, so that in February, 1901, advertisements were published calling for bids for the erection of a bridge in accordance with general specifications prepared by Mr. McGilvray. On the suggestion of Mr. C. A. P. Turner, M. Am. Soc. C. E., of Minneapolis, who had been consulted in the matter, the specifications were drawn to permit either a suspension or stiff girder form of construction.

Bids were opened on March 25, 1901, a few days after the writer assumed the office of City Engineer. But one bid, that of the American Bridge Co., was received, which was for a stiff girder structure on plans prepared by Mr. Turner. Under this proposal the city was to pay $7,000 per year for 20 years. The city immediately applied to the Secretary of War for permission to erect the bridge, but the permit was not finally granted until Sept. 6, 1901.

The American Bridge Co. afterward withdrew its proposal, and the Duluth Canal Bridge Co., A. Y. Bayne, General Manager, submitted a bid on the same plans, which, after some modifications, was finally accepted by the city and a contract entered into with the company. The contract provides that if the bridge is completed on or before Nov. 1, 1902, the price shall be $[illegible],000, if completed after that date, $96,000. Payments are to be made annually, increasing from $[illegible],000 for the first five instalments to $6,000 for the five final instalments, with interest at 4% deferred payments. The company, to demonstrate the practicability of the bridge, agrees to operate it for three months after completion free of cost to the city, and if at the end of this period the city desires a further test the company will operate it for another three months, the city to pay the actual expenses thereof. If the bridge is accepted by the city, it takes possession of it at once and guarantees the bonds of the company, which are made payable in accordance with the terms of the contract.

The plans, as approved, are for a stiffened girder of 393 ft. 9 ins. span, supported on steel towers resting on pile and concrete foundations, with the bottom chord of the bridge 135 ft. above high water. The ferry car is suspended from stiff riveted hangers from trucks running on tracks placed within the bottom chords of the trusses. The structure is shown diagrammatically in Fig. 1, and Fig. 2 is a view from a work drawing.

The car is proportioned to carry a loaded street car weighing 21 tons, and the remainder of the floor loaded with 100 lbs. per sq. ft. The trusses are designed to carry, in addition to their dead weight of 330 tons, a live load of 120 tons, consisting of the trucks and machinery, the hangers and the loaded car. With the assumed wind load of 50 lbs. per sq. ft. against the car and hangers, the live load will be taken entirely off the leeward truss and concentrated on the windward side, so that (with this condition possible) each truss must be designed to carry the entire live load. The live load stresses are increased for impact as follows: 40% for chord members, 60% for posts and diagonals, and 70% for hangers and sub-verticals.

The stresses due to suddenly starting or stopping the car, and to traction, are carefully considered in all affected parts of the structure. Temperature stresses due to a change of 150° F. are provided for in the design. All parts of the structure are calculated for the assumed wind pressure of 50 lbs. per sq. ft. on all exposed areas, including the ferry car and its load. The permissible working stress for soft steel is 15,000 lbs. and for medium steel 17,000 lbs. per sq. in. for tension members. For compression members the following formulas are used:

$$\text{For soft steel:} \quad P = \frac{15{,}000}{1 + \frac{\frac{L}{2}}{13{,}500\ R^2}}$$

$$\text{For medium steel:} \quad P = \frac{17{,}000}{1 + \frac{\frac{L}{2}}{11{,}000\ R^2}}$$

The maximum stresses due to a combination of wind pressure and vertical loading are allowed at 19,000 lbs. per sq. in. for soft steel and 21,000 lbs. per sq. in. for medium steel. The shearing stress in rivets is fixed at 11,000 lbs. per sq. in. for soft steel and 12,000 lbs. per sq. in. for medium steel. The bearing stress allowed is 22,000 lbs. per sq. in. for soft steel and 24,000 lbs. for medium steel.

No material is allowed in the main members which is less than ⅜-in. thick, and in laterals the thickness must be at least 5-16-in. The length of compression members is not allowed to exceed 100 times the least radius of gyration, except in wind bracing, where they may be increased to 125 times. In field riveting, if hand-driven, the total area must be 25%, and if power-driven 10% in excess of areas calculated for shop work. All requirements as to material and workmanship conform to the American Bridge Co.'s standard specifications for steel railway bridges.

The foundations of the bridge are in sand of varying degrees of fineness, extending to a depth of 90 ft. below water level, where it rests on

strata of red clay. The four main piers each consist of 47 piles driven 37 ft. below datum, mean low water in Lake Superior, and cut off 3 ft. 6 ins. below it. Oak caps, 12 × 12 ins., are drift-bolted to the piles, and above is placed a double floor of 12 × 12-in. pine timbers, bolted together and to the caps. On the platforms Portland cement concrete piers are built 8 ft. 6 ins. high and containing about 68 cu. yds. of concrete each. The concrete is mixed in the proportion of 1 part of American Portland cement, 3 parts of sand and 6 parts of crushed rock or beach gravel. The requirements for Portland cement follow the customary specifications as to fineness, soundness, tensile strength and time of setting. The sulphuric acid must not exceed 2%, and the cement must weigh not less than 380 lbs. per barrel. Two anchor bolts are bedded in the concrete for each leg of the piers. Each bolt is 2½ ins. in diameter, and at the lower end has an anchor plate 1 ft. square and ⅞-in. thick. The two main piers, at each end of the bridge, are tied together by means of two 12-in. channels, bedded in the concrete, for the full width of the piers, and placed just below the upper surface.

The piers for the rear legs of the towers rest on the natural soil, excavated 1 ft. below datum. They are of Portland cement concrete, 11 ft. square on the bottom and 6 ft. square on top and 9 ft. in height. Anchor bolts are bedded in them, as in the main piers.

As the specifications require that the ferry car, when at rest, shall not project over the water side of the canal piers, it is necessary to design the supporting towers so that the car can pass between the main columns. This makes a portal of rather unusual dimensions, but as the designer, Mr. Turner, states:

> Upon noting the width of the braced posts, their connection at the bottom, and comparing their height with the width of the post, it will be seen that the proportions, as regards width of the post and the height of the portal, are not far from those which are ordinarily used in nearly all through bridges; while the fact that the posts have a considerable amount of batter places it in even more favorable light.

Owing to the fact that the tracks in the lower chords of the trusses must be continued across the tops of both towers, the contraction and expansion is provided for by placing nests of 4-in. rollers under the base of each post of one of the towers. There are seven rollers, 2 ft. 7 ins. long, under the main posts, and five rollers, 1 ft. 8 ins. long, under the side batter posts. The nests under each main post and its side batter post are connected by making two of the rollers extend from nest to nest. Under each of the rear batter posts are six rollers, 1 ft. 6 ins. long.

The trusses are solid riveted structures of the Pratt type, with curved upper chord, and with sub-panel hangers to bottom chord. The main posts, where necessary, are braced in the plane of least width by horizontal struts to the centers of the panels. The bottom chords are box-section, open at the bottom, with the two channels, of which the posts are constructed, carried down on each side and riveted thereto. The chord is prevented from spreading by means of steel yokes spaced 7 ft. apart. The lower flange of the lower angles support within the box chord suitable rails for carrying the trucks of the ferry car.

The trusses are rigidly connected with the tops of both towers, and the box-section of the lower chords is continued across the towers, the top plates in this portion being hinged so that the trucks will be accessible for inspection and repairs. There are eight trucks, of two wheels each, on each side.

The hangers for supporting the ferry car are of stiff riveted construction and thoroughly braced in all directions to reduce to a minimum the swaying of the car under the action of the wind. To absorb any shock in suddenly stopping the car, short links are placed at the points of suspension of the car from the hangers.

The car will have a central roadway 17 ft. wide and 50 ft. long, with walks 7 ft. wide on each side. The middle 30 ft. of each walk will be enclosed on all sides to form a cabin. The usual ferry gates will be used at each end, and the car will be wired so that electric cars can be handled on it.

The motive power of the car will be electricity. The ordinary speed will be four miles an hour. Owing to the location of the bridge, it is deemed desirable to have a large reserve power, so that if occasion should arise the car can be moved much more rapidly. Duplicate 50-HP. motors will be employed, so arranged that if one is out of order the other can operate the car. The controller will be on the car platform.

The power will be applied by means of a wire rope, supported by automatic drop hangers, placed in the bottom chord and made fast at the outer end of each tower. Above the car it will be carried down through the trucks, over a pulley, and then around a drum, on the side of the car, driven by motors under the car. A hand-power drive is provided on the car for operating it in the event of a stoppage of the current or other interference with the electric power. The car will be coupled to the landing by an automatic coupler, and a buffer, probably a friction buffer of approved design, will be used. As the roadway of the car is about 9 ft. above the grade of the avenue, the city will contsruct the necessary approaches and landing platforms. The walls will be of concrete, surmounted by ornamental iron railings. The sidewalks will be cement, with cement combined curb and gutter, and the roadway will be paved.

If the superstructure of the bridge is erected between Dec. 15 and April 1, falsework will be erected in the canal, leaving a central opening 80 ft. wide and 117 ft. high. If the work cannot be done during this time, other arrangements will have to be made with the War Department.

The Duluth Canal Bridge Co. have sublet the construction of the foundations to Messrs. Hugo & Timms, a local firm, who at this writing are making satisfactory progress.

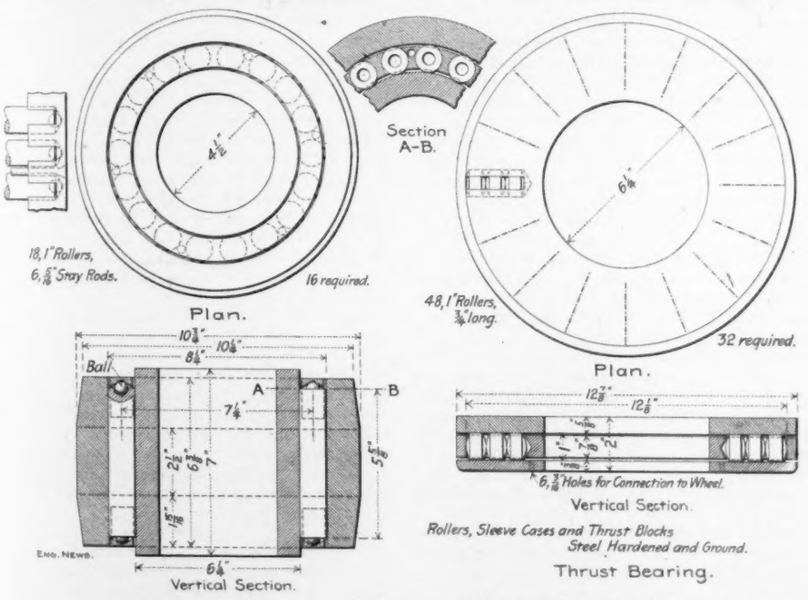


FIG. 13. DETAILS OF TRUCK WHEEL BEARINGS.

The drawings on our two-page plate show all the more important of the details referred to in the preceding description. The location of these various details and their purpose in the structure, to be easily understood, require a little further explanation. Referring to Figs. 1 and 2, it will be seen that the car is rigidly suspended from a stiff platform or truck, which travels on tracks carried by the bottom chords of the truss. Fig. 3 shows the truck with the car suspended from it, and Fig. 4 shows the truck construction in greater detail. The lower chords of the truss are of inverted U-section, composed of two side channel sections and a cover plate. The flanges of the side channels project inward, and on the bottom flanges are carried the tracks, as shown by the drawings of Fig. 5. The truck is hung from wheels running on these tracks by truck hangers of the form shown by Fig. 5. There are 16 of these hangers, eight for each side of the truck. Fig. 6 shows the details of the wheels from which the truck hangers are suspended. Fig. 7 shows the special connections of the web members and bottom laterals to the lower chords of the truss, and also the special cast-steel stiffening yokes. The location of the conductors from which the operating current is taken is indicated by Fig. 3; the details of these conductors and of the trolleys which take the current from them are shown by Fig. 8. The general arrangement and working of the operating cables are described above. Fig. 9 shows the detail by which the ends of the cables are attached to the truss at each end; Fig. 10 shows the supporting sheaves mounted on the truck to carry the cables, and Fig. 11 shows the drop hangers which support the cables between the track and the ends of the truss to prevent sagging. It will be noticed that these drop hangers are so hinged as to swing aside to let the truck pass and then to drop back and catch the cable which trails out behind the truck. Finally, Fig. 12 shows the roller bearings under the tower legs at the expansion end of the structure.

THE PENNSYLVANIA ANTHRACITE COAL FIELDS are described by Mr. H. H. Stoek, in the Third Part of the 22d Annual Report of the U. S. Geological Survey—now in press. In all, 484 sq. miles are underlaid by workable coal measures, though these measures are not continuous, consisting of detached basins. It is estimated that these measures contained 19,500 million tons of coal, before mining began; and Mr. D. A. Smith believes that this amount of coal only represents from 6% or even 1% of the vast original coal deposit, before erosion commenced to remove, or redistribute it. Anthracite coal was first discovered in the Wyoming Valley in 1762; in 1769, Obediah Gore first burned anthracite coal in his blacksmith's forge; in 1802, it was burned in Philadelphia; in 1812, it was first successfully used in an iron furnace at Philadelphia; in 1823 coal was shipped to Boston around Cape Cod; 1820-40 was the period of the canal exploitation of this coal, and in 1840 began railway transport. Anthracite coal is universally mined with hand rotary drills and the use of black blasting powder—though dynamite is sometimes used. The Bureau of Mines reports that one keg of powder will only produce 39.3 tons of anthracite coal, as compared with 282 tons of bituminous coal per keg. The cost of mining anthracite coal is not far from $1.50 per ton; and in 1899 140,656 people were engaged in this industry. The production of anthracite coal is thus set down in decennial periods: 1880, 28,700,000 tons, valued at $42,300,000; 1890, 46,500,000 tons, at $66,400,000; 1900, 57,400,000 tons, valued at $86,000,000. Late concentration of interests and improvements in machinery increased the average daily breaker output from 500 tons in 1887, to 880 tons in 1897. But deeper workings and greater cost in mining have had an effect upon the selling price of prepared sizes at tide water; these were, per ton, $3.26 in 1877; $3.67 in 1887, and $3.46 in 1897. The invested capital in anthracite coal mining amounts to about $700,000,000.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
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ALFRED E. KORNFELD, New York, M. C. ROBBINS, Chicago, S. B. READ, Boston. } ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; *6 months,* $2.50; *2 months,* $1.00. *To all other countries in the Postal Union: Regular Edition, One Year,* $7.00 (31 *shillings*); *Thin Paper Edition, One Year,* $6.31 (26 *shillings*). *SINGLE COPIES of any number in current Volume,* 15 *cents.*

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The Canadian Society of Civil Engineers is experiencing no small difficulties in its attempts to secure legislation to make engineering a "close" profession in Canada. Thus far it has only succeeded in obtaining the desired legislation in Quebec. The bill which it introduced in Nova Scotia two years ago was defeated, and the bills which are now pending in the Ontario and Manitoba legislatures are meeting strong opposition. Other engineering organizations, notably the Dominion Land Surveyors and the Canadian Mining Institute, are using their influence to defeat the measures, and they are severely criticised by such influential newspapers as the Toronto "Globe."

It is of interest to note that this opposition is experienced, notwithstanding the concessions which have been made by the framers of the bill to reduce the strength of the opposition. For example, while the avowed object of the bill is to prevent unqualified persons from calling themselves Civil Engineers, or practising the profession of civil engineering; all persons engaged in civil engineering work prior to the passage of the bill are exempted from its provisions. Again, to counteract the strong pressure which the Canadian engineering schools would be sure to exert against any measure restricting the right of their graduates to practice, the bill exempts those holding engineering degrees from any engineering school authorized by the Canadian Government to grant such degrees. Thus, the graduate of McGill or Toronto universities can hang out his shingle as a "Civil Engineer" immediately on his graduation if he chooses. Notwithstanding these concessions, the students of Queens University, Kingston; and of McGill, have adopted resolutions condemning the proposed legislation. Their opposition is based, apparently, on the ground that the bill will tend to make the Civil Engineering branch of the profession, and the society which represents it, "the whole thing."

In the newspaper discussion on the subject, it has been stated by one of the defenders of the bill that the American Society of Civil Engineers has appointed a committee for the purpose of obtaining similar legislation in the United States. This statement is so wide of the mark that it should be corrected. The general subject of the possible legal restriction of the practice of civil engineering was a topic for informal discussion at the annual convention last June. The discussion revealed a wide difference of opinion among the members, but at its close a committee was appointed to consider the advisability of some "action for the protection of engineers and of the public from incompetent practitioners," and to report at the summer convention of 1902. We need hardly point out that there is great difference between a committee appointed to consider the subject from the theoretical point of view and a committee to undertake the practical work of obtaining legislation.

There is, perhaps, a bare possibility that this committee may be the "entering wedge" for some such action by the society as that taken by the Canadian organization. Unless we greatly mistake the sentiment of the members as a whole, however, such an outcome is improbable to the last degree. The experience of the Canadian Society during the years it has been striving to secure the legislation it desired is the best argument we know of against the proposition to lead the American Society in a similar course.

We do not share the fears of those who anticipate that the passage of the Shafroth bill, now before Congress, would mean the general compulsory abandonment of the present system of weights and measures; but we see no benefit whatever to the country in the measure. This bill would make the use of the metric system obligatory in all departments of the government requiring the use of weights and measures except the survey of the public lands. To carry out such a law would be an unmitigated nuisance and expense in a great number of offices where government work is carried on. In letting contracts, for example, the requirement that all work done under the contract shall be performed by the metric system would be equivalent to adding more red tape to the restrictions already surrounding government work. In the case of machinery, for example, it would restrict competitors to those who were equipped to do work under the metric system. We believe that any such restrictions upon bidders for government work are exceedingly unwise. They add much to its cost, and nothing to its quality. To give a concrete example of the working of such a law. Suppose a government engineer out in the wilds of the West or South has to have a dredge-boat or snag-boat built. To comply with the law, the boat and all her machinery must be built on the metric system. After a season of travail the boat is built, and put at work; but to keep her in repair reliance must be placed on local machine and blacksmiths' shops and hardware dealers. The ordinary standard bolts, nuts, pipe, wire, fittings, etc., must be used, or else everything must be made to order. The former alternative would doubtless be chosen, but why compel by law the absurdity of writing a requisition for a piece of 2-in. pipe as a piece of "5.08 centimeter" pipe, with the chance of having to send a messenger along with every requisition to explain to the storekeeper what is actually wanted.

Again, take the case of the Navy. Would the standards established for gun calibers, ammunition, and a hundred different things about our present war vessels be altered? If so, imagine the confusion in case of war, with some vessels requiring supplies of metric ammunition and some requiring ammunition made on the old standards. Or if the ammunition standards are not to be changed, why not continue to call a 50-lb. shot by its well-known name, instead of writing it down as a 22.6797 kg. projectile?

At present each government department is free to use either the metric or the ordinary system, and various bureaus working in purely scientific fields have adopted the metric system. Whenever other bureaus can find any advantage in a change to the metric system they can do so without any further legislation by Congress; and to repel this change by process of law without a more exhaustive investigation of its effects than has yet been made would be extremely unwise.

The New York legislature is to adjourn on March 27, and the chances of the passage of a canal bill before that time appear to be about evenly balanced, with the scale turning, if anything, against the measure. Even if successful, the appropriation will have to be approved by popular vote at the next election, and it now seems very small chance indeed that such approval can be secured. It is useless to gloss over the fact that the appropriation now pending of $101,000,000 to $37,000,000, is only the entering wedge for further appropriations which will increase the total expenditure on state canal improvements to over $100,000,000, whereas if the most economical route laid down by the engineers were adopted a complete 1,000-ton barge canal could be built for only a little over half this sum. The root of the trouble with the old $9,000,000 "improvement" was that it was based on an estimate of what the taxpayers could be induced to give, without regard to what was actually required for the work. To pass any of the canal bills now pending in the New York legislature would be to repeat the mistake of seven years ago. Those who misled the people in 1895, however, did it for the most part through ignorance. No such excuse exists to-day. The official reports of the commission appointed by Governor Roosevelt, of the engineering board which succeeded it, and of the U. S. Deep Waterway Commission, have furnished the material for an intelligent decision upon this question, and for a far better solution than the wasteful and inadequate scheme now pending.

While the New York legislature is debating whether to spend thirty to forty million dollars in improving its state canals, the Ohio legislature has before it the question of final abandonment and demolition of its state canal system. That the canals have ceased to carry any traffic of importance, and are a mere burden on the state treasury, amounting, according to the statement of the Attorney-General, to about $200,000 per annum, is now generally admitted. The opposition to abandonment comes from the interests along the line of the canals, that depend on them for a water supply which they obtain for a nominal price. There is also opposition from those who fear, very likely with good reason, that the canal lands and rights of way will be acquired by railway or other corporations, and that these interests are really back of the abandonment proposition and will dictate the manner of its accomplishment.

Those who oppose the abandonment of the canals on this ground, however, will do well to alter their tactics and use their influence to have the bill so framed that the state's interests shall be fully protected. The canals are sure to be abandoned sooner or later, and their continued maintenance means not only a constant drain on the state treasury, but the loss of thousands of acres of valuable lands, which are now made swampy and unfit for cultivation by the seepage from reservoirs, etc.

In spite of the rather discouraging outlook for the future supply of wooden ties of good quality at reasonable prices, the steel tie as a substitute for wood receives but little practical attention from railway officers in this country. Even the interest in and use of preservative processes for treating wooden ties are not as widespread as might be expected, in view of the extensive practical experiments that have been made and the satisfactory results that have been attained in durability, economy and the utilization of inferior timbers. In another column we describe a small installation of steel ties on the Lake Shore & Michigan Southern Ry., and in our issue of July 19, 1900, we described another installation on the Huntingdon & Broad Top Mountain Ry. These,

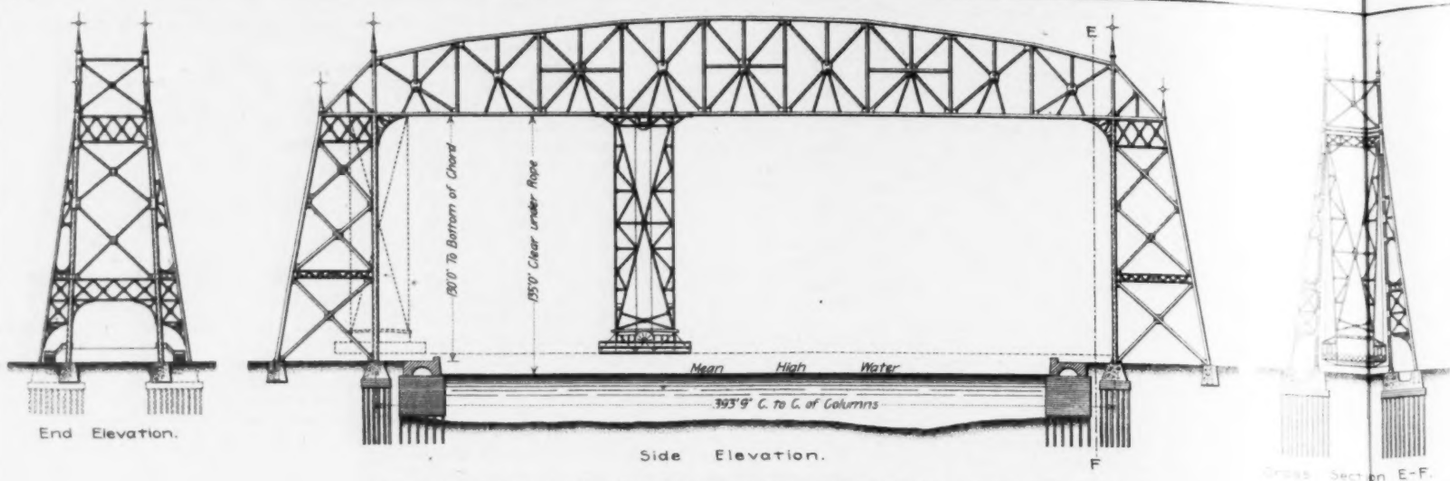


FIG. 1. GENERAL ELEVATIONS AND SECTIONS OF FERRY BRIDGE AT DULUTH, MINN.

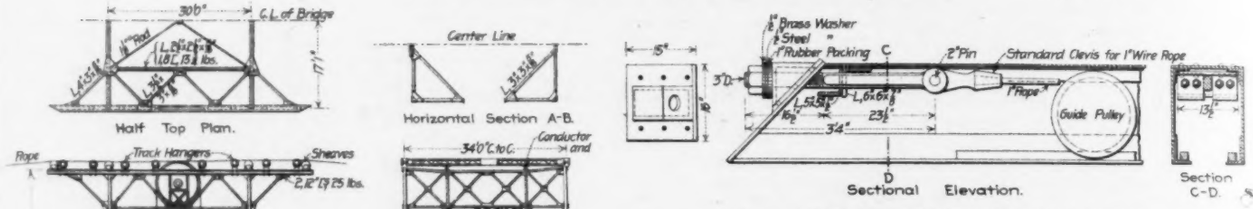
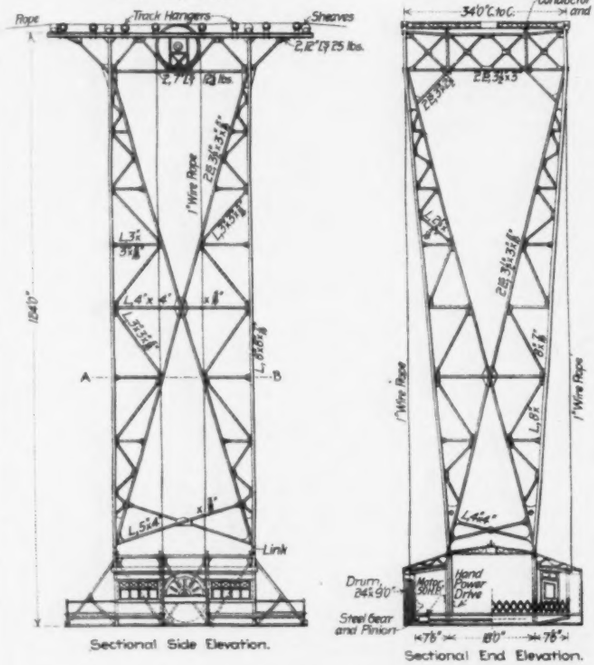


FIG. 9. CABLE CONNECTIONS AT END OF TRUSS.



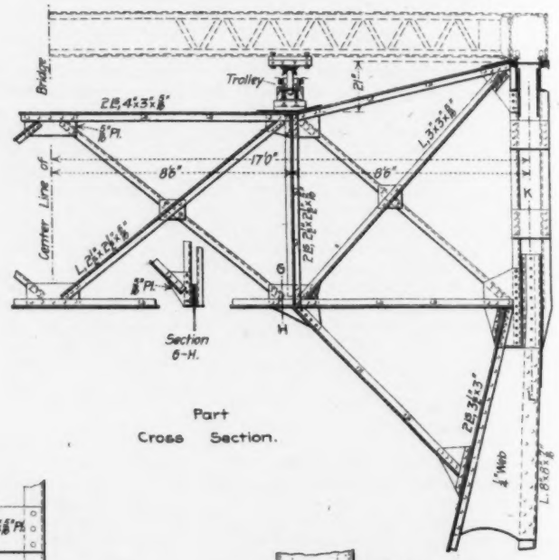


FIG. 3. GENERAL DETAILS OF CAR, TRUCK AND HANGERS.

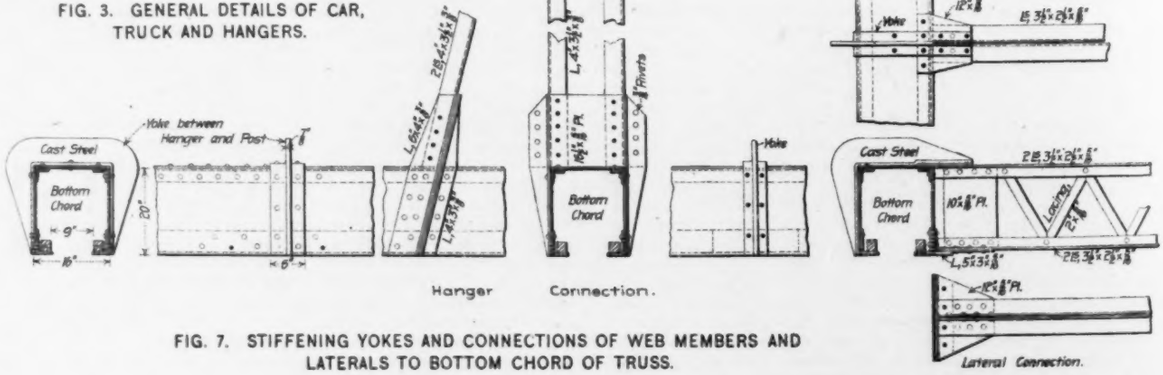


FIG. 7. STIFFENING YOKES AND CONNECTIONS OF WEB MEMBERS AND LATERALS TO BOTTOM CHORD OF TRUSS.

SUSPENDED CAR TRANSFER BRIDGE ACROSS DULU

C. A. P. Turner, M. Am. Soc. C. E., Designing Engineer. W. B. Patton, City Engineer,

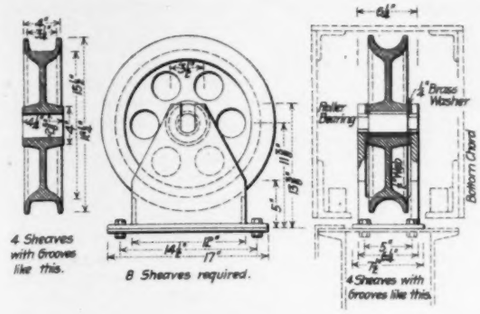
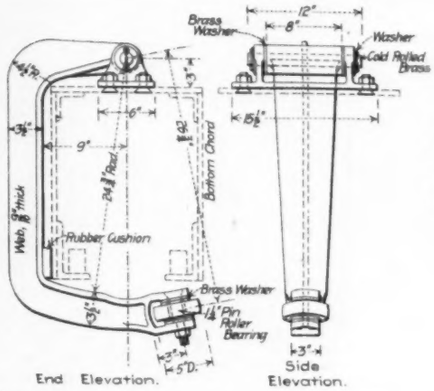


FIG. 10. GUIDE SHEAVES ON TRUCK FOR CABLES.



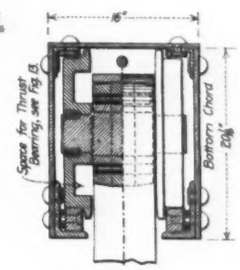
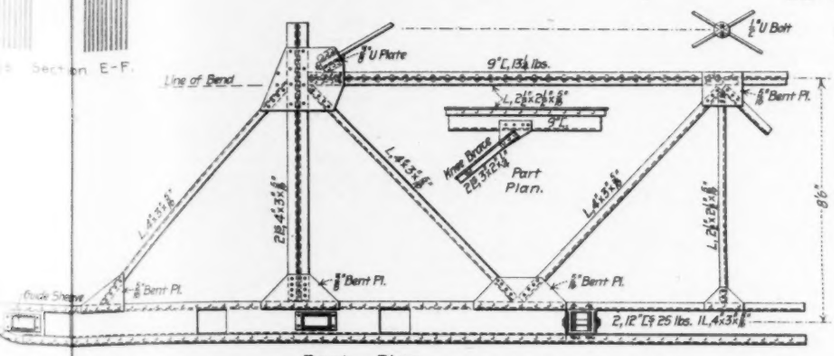


FIG. 6. DETAILS OF TRUCK WHEELS.

Section E-F.



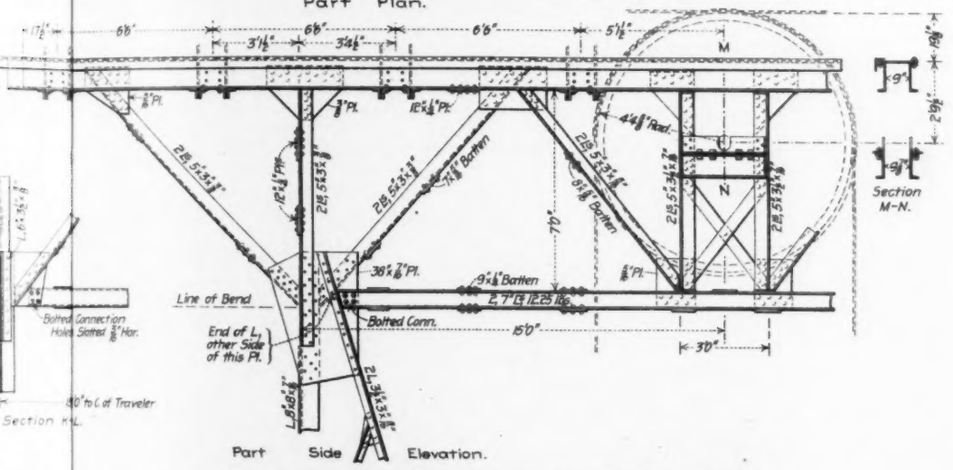


FIG. 4. DETAILS OF TRUCK FROM WHICH CAR IS SUSPENDED.

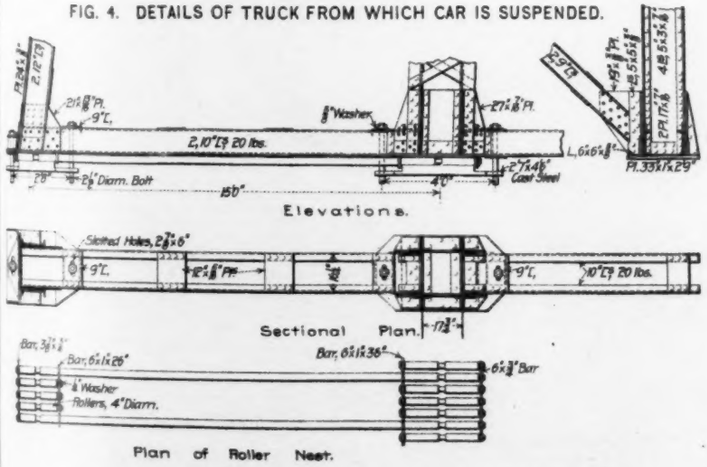


FIG. 12. ROLLER EXPANSION BEARINGS UNDER TOWER LEGS.

FIG. 11. DROP HANGERS TO KEEP CABLES FROM SAGGING.

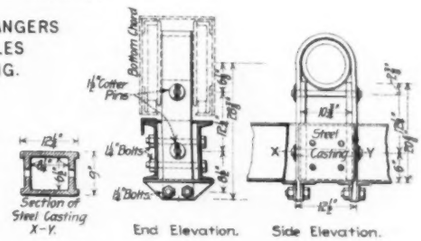
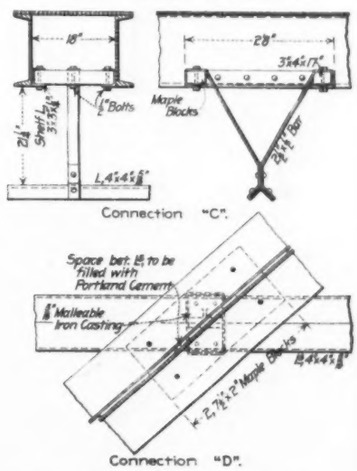
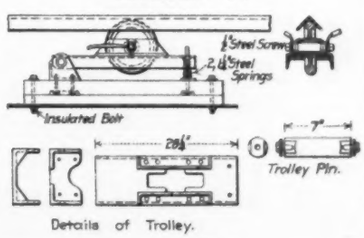


FIG. 5. DETAILS OF TRUCK HANGER.





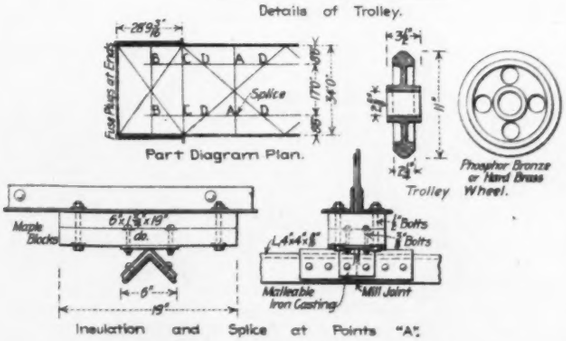


FIG. 8. DETAILS OF CONDUCTORS AND TROLLEYS.

ACROSS DULUTH SHIP CANAL, DULUTH, MINN.

n, City Engineer, Duluth, Minn. Duluth Canal Bridge Co., Duluth, Minn., Builders.

CHAS. HART, LITH., 30 VESEY ST., N. Y.

however, are very exceptional, and can hardly be accepted as any indication of a tendency to adopt or experiment with steel ties. Statements have from time to time appeared to the effect that the use of steel ties in other countries is being abandoned, but while such a change may have been made in certain cases, it is by no means representative of a general tendency in this direction. In fact, the use of metal continues to extend in European and other countries where the timber resources or climatic conditions make their use economical, while in some cases they are even used where good timber is readily obtainable. As far as the practical efficiency of metal ties is concerned, that has long been established beyond all doubt, provided, of course, that the ties are of proper design and manufacture, and have efficient rail fastenings. In this connection the following summary of the metal tie industry in England may be of interest: Steel ties are not used on English railways (with the single exception of a limited extent on the London & Northwestern Ry.), but they are manufactured very largely for foreign railways. A partial record has been kept of published notices of contracts placed in England during the past six years (1896-1901). This very incomplete record shows 55 contracts for metal ties placed within the above period, of which 49 were for India, 3 for Mexico and 3 for Africa. Of the Indian contracts, 39 were for cast-iron bowl and plate ties; all the other 16 contracts were for steel ties. In most cases the quantities are not stated; in some of them, however, the quantities range from 6,000 to 100,000 steel ties per contract, and from 520 to 12,000 tons of cast-iron ties per contract, the former being sold by number and the latter by weight. Some of the contracts were placed by the colonial governments, and others by the railway companies. These figures will give some idea of the importance of the metal tie manufacturing industry in England alone. In other countries, particularly Germany, Holland and Belgium, the manufacture of metal ties for domestic and foreign railways is also an important item in the steel industry. The above remarks apply only to ordinary railways, but steel ties are also very extensively used for light, portable and industrial railways, and for street railway track.

CENTRAL HEATING PLANTS IN THE UNITED STATES.

The rapid centralization of all kinds of industries is well illustrated by the recent growth of commercial central heating stations. This class of public service, the very existence of which is known to comparatively few, has already been introduced in nearly a hundred cities and towns of the United States. The actual number of places included in the accompanying table of central heating stations is 82, or within one of the number of water-works in the United States in 1850. The 83 water-works, however, included all plants in existence, regardless of size, and the list was compiled after many years of inquiry. The central heating stations, on the other hand, are all located in places of 3,000 population and upwards, and this is the first list of the kind ever published. Including a very few plants outside the limits of the table, and a few possible omissions within those limits, the number of central heating stations in the whole country to-day is somewhat in excess of the public water-works systems of 50 years ago.

Before proceeding further, it should be explained that central heating stations is used to denote plants which supply steam or hot water heating for commercial gain, and that the term does not include plants for the service of institutions and industrial establishments, nor for heating by artificial or natural gas, nor by electricity. It may also be stated that the information presented will form a part of the Introduction to "The Municipal Year Book," a publication which we have had in hand for some time, and which is now nearly completed.

The geographical distribution of the 82 plants under discussion, the populations of the places in which they are located, the names of the companies which own them, and the other services, if any, rendered by the same companies, is shown by Table I. In Table II. the geographical distribution of the plants is given, and also their classification under the two heads independent or combined.

Geographically, the plants are scattered across the country from New Hampshire to Washington, and from Minnesota to Georgia and Texas. The single state of Pennsylvania has 22 of the 82 municipalities in the table, or more than one-fourth of the total, against a little less than one-tenth of the number of cities and towns included in "The Municipal Year Book." Illinois comes next, with 15 places in the table. Altogether, 19 states have central heating facilities, against a total of 51 States and Territories, including Alaska and the District of Columbia. While, as already stated, the geographical range is great, yet most of the plants are in the distinctively cold northern tier of States, one each in Georgia and Texas being the exceptions to this rule. The brief description of the plant at Atlanta, Ga., published in our issue of Jan. 31, 1901, indicated that there is an opportunity, however, for plants in the South.

The large number of plants in Pennsylvania, Ohio, Indiana and Illinois, 49 altogether, may indicate that cheap coal and natural gas stimulate rather than retard the establishment of steam and hot water heating plants. But it is notable that most of the independent plants are located in these same States, where, it may be presumed, there is no great object in attempting to utilize the waste steam from electric light and power plants.

The size of the various municipalities in question ranges from New York, with its 3,437,202 people, to Phillipsburg, Pa., with only 3,266 inhabitants. Each extreme in size has an independent steam heating plant. The service of the New York Steam Co., it may be added, covers only a small portion of the business section of Manhattan Borough, but in general only a small percentage of the population of any of the municipalities is served with heat from a central source.

Leaving extremes in population, it is interesting to note that while 6 of the 82 cities have populations of 100,000 or more, 37 have less than 10,000, and 16 less than 5,000 inhabitants. How profitable or otherwise the several plants may be cannot be stated here, but evidently the fact that a place is small has not shut it out of all the advantages pertaining to central heating plants.

To many of our readers the most interesting feature of this exhibit will doubtless be the various combinations of central heating with other public services, as shown by Table III. Of the 45 combined plants, 40 are associated with the electric lighting service, or with this and gas

TABLE I.—COMMERCIAL CENTRAL HEATING STATIONS IN PLACES OF 3,000 POPULATION AND UPWARDS BY THE U. S. CENSUS OF 1900.

City or town.	Population.	Owner.	Independent or combined with:
Laconia, N. H.	8,042	Belknap El. Power Co.	Independent.
Springfield, Mass.	62,059	Springfield El. Lt. Co.	Gas Wks.
Pawtucket, R.I.	39,231	Pawtucket El. Lt. Co.	El. Lts.
Fredonia, N. Y.	4,127	Dunkirk & Fredonia R. R. Co.	El. Lt. and Rys.
Geneva, N. Y.	10,433	Geneva Steam Htg. Co.	Independent.
Lockport, N. Y.	16,581	American District Steam Htg. Co.	Independent.
Newark, N. Y.	4,578	Newark Lt., Heat & Power Co.	El. Lts.
New York, N. Y.	3,437,202	New York Steam Co.	Independent.
N. Tonawanda, N.Y.	9,069	The Fidelity Co.	Independent.
Allentown, Pa.	35,416	Allentown Heat & Power Co	Independent.
Bellefonte, Pa.	4,216	Bellefonte Gas Co.	Gas Wks.
Bloomsburg, Pa.	6,170	Bloomsburg Steam Heat & El.Lt. Co.	Independent.
Clearfield, Pa.	5,081	Clearfield Steam Htg. Co.	Independent.
Erie, Pa.	52,733	Home Htg. Co.	Independent.
Greenville, Pa.	4,814	Peoples El. Lt., Heat & Power Co.	El. Lts., Gas Wks.
Harrisburg, Pa.	50,167	Harrisburg Steam Heat & Power Co.	Independent.
Hazleton, Pa.	14,230	Hazleton Steam Co.	Independent.
Johnstown, Pa.	35,936	Johnstown Power & Heat Co.	Independent.
Lebanon, Pa.	17,628	Lebahon Steam Htg. Co.	Independent.
Mahanoy City, Pa.	13,504	Charles D. Kaier Co.	Independent.
Mt. Pleasant, Pa.	4,745	Peoples Htg. Co.	Independent.
Phillipsburg, Pa.	3,266	Phillipsburg Steam Htg. Co.	Independent.
Pottsville, Pa.	15,710	Pottsville Steam Heat & Power Co.	Independent.
Reading, Pa.	78,961	Reading Steam Heat & Power Co.	Independent.
Scranton, Pa.	102,026	Economy Lt., Heat & Power Co.	Independent.
		Scranton Heat & Power Co. (?)	Independent.
Shenandoah, Pa.	20,321	Shenandoah Heat & Power Co.	Independent.
Towanda, Pa.	4,663	Not given	Not given.
Washington, Pa.	7,670	Steam Htg. Co.	Independent.
Wilkes Barre, Pa.	51,721	Wilkes Barre Heat, Lt. & Power Co.	Independent.
Wilkinsburg, Pa.	11,866	Pennsylvania Heat & Power Co.	Independent.
York, Pa.	33,708	York County Traction Co.	El. Ry.
Atlanta, Ga.	89,872	Atlanta Ry. & Power Co	El. Ry.
Columbus, O.	125,560	Indianola Land & Power Co.	Independent.
Coshocton, O.	6,473	Merchants El. Lt. & Power Co.	Gas Wks., El. Lts.
Tiffin, O.	10,989	Edison El. Lt. & Power Co.	El. Lts.
Toledo, O.	131,822	Toledo Htg. & Ltg. Co.	El. Lts.
Washington C.H.,O.	5,751	Washington Smead Hot Water Co.	Independent.
Youngstown, O.	44,885	Youngstown Steam Htg. Co.	Independent.
Bedford, Ind.	6,115	Heat, Lt. & Power Co.	El. Lt., El. Ry.
Bloomington, Ind.	6,460	Peoples Lt., Heat & Power Co.	El. Lts., Gas Wks.
Indianapolis, Ind.	169,164	Home Heat & Lt. Co.	Independent.
La Porte, Ind.	7,113	La Porte El. Co.	El. Lts.
Terre Haute, Ind.	36,673	Terre Haute El. Co.	El. Lts., El. Ry.
Vincennes, Ind.	10,249	John Hartigan Co.	Independent.
Alton, Ill.	14,210	Alton Ry., Gas & El. Lt. Co.	Gas Wks., El. Lts., Ry.
Belvidere, Ill.	6,937	Belvidere Htg. Co.	Independent.
Bloomington, Ill.	23,286	City Dist. Htg. Co.	Independent.
		Consumers Heat & El. Lt. Co.	Independent.
Champaign, Ill.	9,098	Champaign & Urbana Gas & El. Ry. Co.	Gas Wks., El. Lts., Ry.
Danville, Ill.	16,354	Danville Gas, El. Lt. & St. Ry. Co.	Gas Wks., El. Lts., Ry.
DeKalb, Ill.	5,904	DeKalb El. Co.	El. Lts.
Evanston, Ill.	19,259	Evanston Yaryan Co.	Independent.
Jerseyville, Ill.	3,517	Jerseyville Lt., Heat & Power Co.	El. Lts.
La Salle, Ill.	10,446	Marquette Heat & Lt. Co.	Independent.
Mattoon, Ill.	9,622	Mattoon Heat, Lt. & Power Co.	El. Lts.
Paris, Ill.	6,105	Paris Gas Lt. & Coke Co.	Gas Wks., El. Lts.
Pontiac, Ill.	4,266	J. A. Carrothers, in charge	Independent.
Springfield, Ill.	34,159	Springfield El. Lt. & Power Co.	El. Lts.
Taylorville, Ill.	4,248	Taylorville El. Co.	El. Lts.
Urbana, Ill.	5,728	Urbana Lt., Heat & Power Co.	El. Lts.
Janesville, Wis.	13,185	Janesville El. Co.	El. Lts.
Kenosha, Wis.	11,606	Kenosha Gas & El. Co.	Gas Wks., El. Lts.
La Crosse, Wis.	28,895	Central El. Co.	El. Lts.
Cedar Rapids, Ia.	25,656	Cedar Rapids El. Lt. & Power Co.	El. Lts.
Davenport, Ia.	35,254	Davenport Gas & El. Co.	Gas Wks., El. Lts.
Des Moines, Ia.	62,139	Des Moines Steam Htg. Co.	Independent.
Grinnell, Ia.	3,860	Carney & Hammond	El. Lts.
Mason City, Ia.	6,746	Brice Gas & El. Co.	Gas Wks., El. Lts.
Muscatine, Ia.	14,073	Muscatine El. Ry. Co.	Gas, El. Lts., Ry.
Perry, Ia.	3,986	Perry El. Lt., Power & Heat Co.	El. Lts.
Red Oak, Ia.	4,355	Red Oak El. Co.	El. Lts.
Albert Lea, Minn.	4,500	Albert Lea El. Co.	El. Lts.
Crookston, Minn.	5,359	Crookston W. Wks., Power & Lt. Co.	W. Wks., El. Lts.
Owatonna, Minn.	5,561	Owatonna Gas, El. & Htg. Co.	El. Lts.
Topeka, Kan.	33,608	Edison Illum. Co.	El. Lts.
Bismarck, N. Dak.	3,319	Hughes El. Co.	El. Lts.
Grand Forks, N.Dak	7,652	Grand Forks Gas & El. Co.	Gas Wks., El. Lts.
Butte, Mont.	30,470	Phoenix El. Co.	El. Lts.
Waxahachie, Tex.	4,215	Waxahachie El. Lt. Co.	El. Lts.
Colorado Spgs, Colo	21,085	Colorado El. Co.	El. Lts.
Denver, Colo.	133,859	Denver Steam Htg. Co.	Independent.
Seattle, Wash.	80,671	Seattle Power & Heat Co.	Independent.
Boise, Idaho.	5,957	Artesian Hot & Cold Water Co.	Water-Works.

TABLE II.—Distribution of Central Heating Stations by Totals and by Independent and Combined Plants.

State.	Total.	Independent or combined—Ind.	Comb.
New Hampshire	1	1	..
Massachusetts	1	..	1
Rhode Island	1	..	1
New York	6	4	2
Pennsylvania	22[1]	18	3
Georgia	1	..	1
Ohio	6	3	3
Indiana	6	2	4
Illinois	15	5	10
Wisconsin	3	..	3
Iowa	8	1	7
Minnesota	3	..	3
Kansas	1	..	1
North Dakota	2	..	2
Montana	1	..	1
Texas	1	..	1
Colorado	2	1	1
Washington	1	1	..
Idaho	1	..	1
Total	82[1]	36	45

[1] Including one plant in Pensylvania for which no details are given.

TABLE III.—Number of Central Heating Stations Combined With:

Electric lights	24	Gas works	2
" " and gas works	8	Water-works.[1]	1
" " and railways	3		
" " and water-works	1	Total in combination	45
" " gas wrks, El. Rys	4		
	40		
Electric railways	2		

[1] Artesian hot water.

works, or railways or water-works, or some further combination of these latter. There are four instances in which a single company operates central heating, gas, electric lighting, and railway plants.

This combination of electric service, whether lighting or railway, or both, with central hot water or steam heating is of comparatively recent date, and bids fair to be one of the features of municipal life in the near future. Its ultimate success or failure, at least as a private venture, will, of course, depend upon whether or not it can be made profitable, and this time alone can prove. The most uncertain elements seem to be depreciation and maintenance charges, as opposed to operating expenses, and the popularity of the service. The latter, of course, will depend largely upon its cheapness, as compared with other methods of heating, but in communities made up of well-to-do residents, convenience, absence of coal dust, ashes and soot might be almost as important factors as cheapness. This will be particularly true where soft coal is used, and in such localities central heating may become an important question of municipal policy. In the matter of smoke prevention, alone, central heating plants might prove to be of inestimable advantage to many cities.

In conclusion, it may be explained that no attempt has been made to show the relative extent to which steam and hot water heating are supplied in these 82 cities, because the topics covered by "The Municipal Year Book" are too many and varied to admit of detailed treatment, particularly in a first issue. It is hoped that the interest shown in central heating will be such as to warrant going into more detail in the future, and to that end communications calling attention to errors and omissions, and supplementing what has thus far been attempted, will be heartily welcomed. Descriptions and statistics of existing plants would be particularly valuable for use in making a more thorough presentation of the subject.

LETTERS TO THE EDITOR.

Concrete Roadbed Construction for Street Railways in Kansas City.

Sir: I was very much interested in the article in your issue of March 6, relating to the various methods of track construction, and believe, as you indicate, that the solution of the problem of a material to take the place of ties will be to use concrete. I would say that we have made some slight changes since our use of that material for construction; for instance, we bring the bed of concrete up to 6 ins. below top of rails and then make the filler under the rail trams of sand and Portland cement, mixed in proportions of 2 to 1. While this mixture is more expensive than the concrete, the extra expense is offset in the less amount of labor required to keep it in place until it sets well up against and adheres to the rails. We have also changed the original mixture for concrete to 1 part of cement, 2 parts of sand and 4 parts of crushed rock. Originally we used imported Portland cement, and in order to keep the cost down, we added an equal amount of domestic cement, which mixture we found by experiment formed a perfect crystal. Now, for the same ultimate price of the concrete, we are able to use the best grade of American Portland cement. Also, where the ground underneath the concrete beam is questionable in relation to obtaining a good foundation, we increase the surface bearing somewhat by widening the concrete trench according to the soil we have to contend with.

Very truly yours, E. Butts,
Chief Engineer, Metropolitan St. Ry. Co.
Kansas City, Mo., March 14, 1902.

The Non Continuous Swing Bridge Again.

Sir: Some 23 years ago the writer discussed with other engineers the various general methods by which swing bridges could be made non-continuous, viz: (1) by the toggle point C D C, (2) by the pulling bars C C, (3) by spreading B B,, (4) by lifting whole span under B B, (5) by lifting the ends A A.

The first method can be operated by screws, wedges or preferably rams; the second can be operated by a right and left screw with a worm, pinion or other device; the third by hydraulic rams; the fourth by rams, as at Raritan Bay; the fifth by rams, toggles or wedges. The late C. Shaler Smith prepared a plan, and I think built it, on the first method, and I am under the impression that the fifth was employed at the Westport bridge on the New York & New Haven R. R. The Raritan bridge was discontinuous when closed and I believe worked very satisfactorily.

After a careful study of these various methods both from the points of view of the mechanical details and the required time and power to operate, I concluded that for bridges of any magnitude the fourth and fifth methods only were satisfactory.

If Mr. Worthington succeeds in making his plan work satisfactorily he will deserve great credit, but I think he does not give his own design as severe a criticism as he would undoubtedly do in other cases.

The friction on his screws, hinge joints and toggle-bars will be very heavy. His estimate of 20% friction requires lubricated joints with low pressures. As he quotes Unwin, allow me to also quote him:

> There are cases in which pressures, even of a ton or more per sq. in., are carried by lubricated journals without danger of seizing. In most of the cases where excessive pressures are carried, it appears that the pressure is intermittent or reverses in direction so as to come alternately on the two brasses. In such cases it is conceivable that the oil finds a way in during the relief of pressure and is not squeezed out in the short period in which the pressure acts."

Also, in the same table, where Mr. Worthington gets his 3,000 lbs. on "crank pins of shearing machines," he will find that the highest pressure given for the reciprocating joint is "crank head neck journals, 1,200 lbs."

I have no other interest in this matter than a professional one, and having pointed out that part of the problem where the real design comes in, I will drop the subject. Old Fogy.

New York, March 14, 1902.

Relining Railway Curves.

Sir: Having read with interest the several articles in recent numbers of Engineering News on the subject of relining railway curves, the writer offers the following method, which he has used with success for several years.

For relining curves which do not exceed 1,000 ft. in length, or 30° angle, of course the best and simplest method is to produce the main tangents to an intersection, and by measuring the external distance find the degree of curve that will run through the desired point opposite the P. I.

With long curves of 20 stations or more, however, it is impracticable to run the tangents to an intersection; and even if that were done it is often the case that a simple circular curve which would come in the center of the track at one part of the curve would run so far away from it at other places as to make it impracticable to use it unless extensive improvements were being made in the track at the time, the object sought being to produce the best riding curve for the least expenditure of labor; or, in other words, with the least possible "throw"—and the throw is often restricted to narrow limits by the width of the roadbed or obstructions along the track.

Let the sketch represent a curve, say 20 stations long, in which all the original transit points have been lost. Take the point E, approximately in the middle of the length of the curve, and the points D and F, say 500 ft., or where they

can be seen from E, all in the center of the track. Now, as a circle can be drawn through any three points, the angle between the two chords D E and E F is half the total angle of the circular curve through these three points, the degree of which is found by dividing this total angle by the length of the curve from D to F. Keeping the transit at E, this portion of the curve can be staked out at once, and as it is in the center of the track at three points, there will be but little throw.

To complete the curve, if no spirals are to be used, set up at F and turn tangent to the curve just run and intersect this tangent with the main tangent at G; then from R = T Cot. ½ △, the radius and degree of curve are found of the curve that will end in the tangent at H.

This will of course result in a slight compound at F, but this is generally found not to exceed 3' to 5' change in D°.

If spirals are to be introduced, the following is adapted to any of the methods for spirals when the offset or shift from the main to the imaginary tangent is used as a function of the spiral, particularly in the method of Prof. Talbot in the railway "transition spiral." Using the left side of the figure, produce the tangent to the central portion at D to intersect the main tangent at K; measure D K and find—for trial—the radius of the circular curve that would end in the main tangent M, the same as described above. But in place of this it is required to find the curve which will end in the offset tangent to make room for the spiral. Calling the angle at K, △ and the radius of the curve D M, R', the radius of the curve D B, R, and the distance between the two tangents O, we h

by Searles $R = R' - \frac{O}{\text{vers } \triangle}$. Dividing △ by D° f

the length of curve D B, and this, minus half the le of the spiral, gives the length of curve D C. D C the length of the spiral equals the whole length D A.

It is the practice of the writer to measure the dista D A along the center of the track from D and se point A on the tangent, and then run the spiral fro towards C and then the circular curve from C to D, clos on D for a check. The point D should be at least 50 from the original P. C., and where the degree does exceed 4° the compound at D generally does not ex 0° .05', which is, of course, unnoticeable when riding curve. This method is rapid and requires but little p liminary work and but few calculations in the field.

A. L. Grandy,
Supervisor Erie R. R.
217 Spicer St., Akron, O., March 3, 1902.

Pecos Valley Rock-Fill and Earth Dam No. 2, Near Eddy, N. M.

Sir: Talking about dams of peculiar types and make it may be of interest to your readers to note the followin facts:

In Mr. Wegmann's very admirable book on "The desig and construction of dams," 4th edition, p. 129, is given sketch of a certain dam in the Pecos Valley, N. M

Sketch (Reversed) of Pecos Valley Dam No. 2.
(Reproduced from Wegmann's "The Design and Construction of Dams.")

which section is here reproduced. An error has been made in showing the water on the wrong side of this dam, and this is accentuated by the following description in the text:

> In these dams leakage was stopped very successfully by forming the downstream part of the dam of earth.

As Mr. Wegmann is such a high authority on the construction of dams, it would seem that in this instance it would be a friendly act to the profession to get the water around on to the right side of the dam, which would be on the side next to the earth slope, because some engineers who do not know of the real condition of affairs might be misled by the plan shown by Mr. Wegmann. Outside of the fact that manifestly the water should be on the earth, or impervious, side, the true condition of affairs is shown in Mr. James D. Schuyler's recent excellent book, "Reservoirs for Irrigation," page 53. Western Engineer.

Los Angeles, Cal., March 6, 1902.

(An earlier rock-fill and earth dam was built below the one mentioned above. Its crest was overtopped and the structure badly damaged. It was subsequently rebuilt to a height of 45 ft., or, according to Mr. Schuyler, 48 ft., but with flatter slopes. For the interesting history of the first dam, with details of construction, see Engineering News for March 17, 1890; Aug. 17, 1893; Jan. 18, 1894; and Sept. 17, 1896.—Ed.)

Construction of Earth Dams; Experience with Otay Rock-Fill Dam.

Sir: I have read with a great deal of interest your editorial on earth dams in your issue of Feb. 20. Fully twelve years ago Major Scott, of the Engineering Corps of the English army, was a temporary resident here. As he had had charge of the building of a great many dams in India, I learned from him the preference they have over there for earth dams, and how they build them. He said they packed them by having a herd of sheep or goats on one slope of the dam while they were filling the other slope to a depth of, say, 4 to 6 ins. The feed boxes for the herd were on each end of the dam. The nature of the goats was such that when they saw a goat eating anywhere they generally thought he had food which was a little better than they had, and being greedy, started after the goat. This kept the herd of several hundred goats going from one side to the other, packing the dam better than any other known means.

The question of core was very frequently discussed between us, and he gave as his opinion that proper clay was sufficient, provided the slopes were easy. It was from what he said, and owing to necessity, that caused us to complete the Lower Otay dam, after we had built up with masonry about 10 ft. above the bed of the stream with boiler plate core, which your paper fully described in your issue of March 10, 1898.

The Otay dam has not had a full pressure, but has had a 61-ft. head as a maximum for several years. It is

nothing but loose rock on either side, and the core makes it impervious. We have not had rain enough since the completion of the dam, about three years ago, to fill the reservoir. Yours respectfully,

E. S. Babcock,
President Southern California Mountain Water Co.
Coronado, Cal., March 8, 1902.

Some Thoughts Suggested by the Recent Failures of Dams in the South.

Sir: The recent failures of four large dams in the South has suggested some thoughts, which, to the writer, appear to have a very important bearing both to the engineer and the investor. Reference is made to the four dams which failed on Dec. 29, all of which have been described, illustrated and variously discussed in recent numbers of the Engineering News. All of these dams were of the same type; that is, masonry dams, built across the beds of large rivers, on solid bedrock foundations, with the waste and flood waters passing over their crests, practically the entire lengths of the dams. Three of the dams, namely, those at Anderson, S. C., Columbus, Ga., and the lower dam at Tallassee, Ala., had trapezoidal sections, the greater batter in each case being on the downstream side of the dam; but no effort was made to provide a rollway for the overflow water. One of them, the Upper Tallassee dam, has an ogee face on the downstream side, the intention as stated by the designer being to provide a rollway over and along which the overflow water would pass. But an inspection of this rollway would show that it could only act as such with a small or medium depth of water on the crest.

The writer is not definitely informed what was the maximum depth of water on the crest that these dams were expected to have at time of flood; except that it was known that the dam at Columbus, Ga., would have at least 10 ft. He has also been informed that the designer of this dam stated that it had a factor of safety of five, when 12 ft. of water should flow over the crest.

When the dams failed, the one at Anderson, S. C., had 7 ft. 6 ins. of water flowing over its crest; the one at Columbus, Ga., 10 ft. 2 ins. over the highest point of the flash boards, or 13 ft. 2 ins. over the top of the masonry; the Upper Tallassee dam had 10 ft. 4 ins., and the Lower Tallassee dam, 6 ft. 8 ins.

In the opinion of the writer, the failures of all these dams was due to too light a section; in other words, the "factor of safety" was too low. If we investigate the stability of these dams against overturning under the conditions they were in when failure occurred—applying only the static head or load of the water, and figuring the weight of the masonry at 140 lbs. per cu. ft.—we find that the Anderson dam had a factor of safety of 1.1; the Columbus dam, 1.5 (considering the dam without flashboards); the Upper Tallassee dam, 1.8; and the Lower Tallassee dam, 1.6.

In arriving at the above results no account was taken of the backwater, or of the weight of the water on top of the dam, as in none of the dams were these factors of sufficient amount or value to add much, if anything, to the resisting moment. While the masonry was figured at 140 lbs. per cu. ft., which is a low value for this class of rubble masonry, still I think it too high a figure to use, with safety, under these conditions.

As before stated, I am of the opinion that these dams failed because the section was too light, or the "mass" of the masonry was not great enough. In the foregoing investigation no attempt was made to fix a definite value or amount to the impact or dynamic action of the water, yet it is well known by engineers and all who have had experience with, or observed the action of large volumes of rapidly-flowing water, such as large rivers at times of flood, that the striking force of the water is, under certain conditions, very great; and that currents of unknown strength and location occur throughout the entire mass of water, from the bed of the stream to the surface of the water.

Every engineer recognizes how difficult and problematical it would be to attempt to fix a value to any of these factors which would be of any service in determining the design of a dam; so it would appear that the only alternative left is to assume, or take, the severest conditions under which the dam can possibly be placed, and then make an ample increase in the section to provide for these unknown factors; in other words, instead of having a factor of safety of about 1.5, let it be at least 4, with the greatest possible depth that can occur on the crest.

No one questions the stability of these dams under ordinary conditions, for they have safely passed water over the crests, some of them as deep as 6 ft. It is a significant fact, however, that no dam of this class (that is, ordinarily high masonry dams acting as overflow weirs) of recent construction, within the knowledge of the writer, have passed safely more than 10 or 12 ft. depth of water on the crests, except where relieved by submergence or backwater.

The Austin dam was designed to pass a maximum depth of 15 ft., yet it failed with only 11 ft. on the crest; and while the faulty character of the foundation doubtless contributed to its failure, there are other facts and statements made in connection with the failure which tend to the conclusion that the dam failed by sliding on itself at, or near the face, and would have failed in this manner regardless of the nature of the foundation.

Is it impossible, or perhaps I should say impracticable, to build an economic masonry dam across the bed of a large stream which can safely pass more than 10 or 12 ft. of water over its crest?

No engineer will, I am satisfied, answer this question with a negative. Yet, it might be well for us to consider for a moment what is understood by the word "economic," used in this connection. It should be taken to stand, not for the actual money cost of the dam itself, but the relative cost of the dam to that of the entire project, such as the development of a water power, installation of all kinds and classes of machinery, transmission lines, real estate, etc.; also the value or importance of the dam to the entire plant as affecting its permanency and continuity of operation. Viewed in this light a difference in first cost of $50,000 or even $100,000, in the dam of a plant the total investment of which is $500,000 or $1,000,000, would be an insignificant sum. Suppose a few thousand dollars more had been spent on the Austin dam in making the section larger, what would have been the value of this enterprise? With a little time and effort, we could soon show what a few thousand dollars, if it had been spent in making these four dams we are now discussing a little heavier, would have saved, in time lost and repairs which must be made, to the owners of these plants, and the various industries dependent upon them for power.

I think the trouble is, that in our efforts to minimize first cost, and our zeal to "promote" the building and development of such enterprises, engineers have "skinned" down the sections of their dams, and gone a little too far to be safely within the limits of "good practice." But engineers are not alone to blame for this fault. It too frequently happens that when an engineer makes a design of the dam, or structure, with an estimate of its cost, and presents it to his clients, he is ridiculed for his extravagance, and told plainly that he must devise a cheaper plan. About the first place he "cuts" is the dam, knowing it is strong enough for all ordinary conditions, and trusting to "luck" for the rest. The company saves a few thousand dollars in the cost of the dam, and in a few years lose ten times the amount saved, by damage and lost time to the plant. Is such a dam an economic one?

I have been much interested in the correspondence and discussions of the relative merits of grouted and hand-laid rubble masonry. While I do not approve of the grouting method, or rather, while I think it should not be entirely relied upon to supply the matrix or binding material for a masonry wall, it is for other reasons than those of merely filling the voids.

An examination of the dam at Columbus, Ga., shows that the portions where grouting was employed, that is, the interior of the dam, has far fewer voids than the part where grouting was not used, and the joints and beds were hand-laid, and I do not doubt that this is true in nearly every instance where grouting is used.

In the particular instances we are discussing, however, I do not think that the constructive features of the dams played a very important part in their failures. Of course I do not mean to say that all rubble masonry is good, or that some is not very poor. A personal examination of the dam at Columbus, Ga., and a knowledge of the method of construction, proves it to be as good grade of work and masonry as is expected for this class.

The foregoing investigation of their stability, and a critical inspection of their cross-sections shows that under the conditions they were in at the time of failure, nothing but a monolithic structure and one of great tensile strength at that, could have safely withstood the stresses. As all of these dams were rubble masonry structures, it should not have been expected of them to withstand greater forces than this class of masonry is known to safely stand.

So, as before stated, in the opinion of the writer the failures of these four dams is directly attributable to the use of too light a section; or a false idea of economy in design of this feature of power development.

Robert L. Johnson.

Columbus, Ga., Mar. 1, 1902.

Notes and Queries.

If "Contractors" will send us their name and address for our own use, we will attempt to give them the information asked for.

L. E., Buffalo, N. Y., writes that the methods used in constructing the Forbes Hill reservoir, near Boston, described in our issue of March 13, are almost identical with those used in building the Hiland Ave. reservoir at Pittsburg, Pa., 25 years ago. This reservoir holds about 120,000,000 gallons, however, as compared with only 5,000,000 gallons for the Forbes Hill reservoir.

B. H., St. Louis, asks:

Which are the best arranged, best equipped and best managed shops and drafting offices for bridge and structural work in the United States?

We do not know, and if we knew, we should hesitate to answer a question of this sort on which opinions must greatly differ. A description of a number of the principal bridge works in the United States was given in a series of papers printed in Vol. 39 of Engineering News (Jan.-June, 1898). There have been many changes since that time, however.

J. B. B., San Francisco, Cal., writes:

In making some engineering estimates, I need the coefficient of friction between ice (or hard-packed snow) and wood or iron. Diligent search in the libraries of this city has thus far failed in finding it. There was one statement to the effect that it had never been determined. Can you give me any information or references where I can probably find it? My search has been under the captions of Ice, Friction, Coasting, Toboggans and Ice-boats.

We know of no published data; but practical experience indicates that the coefficient, especially in the case of hard smooth ice, is exceedingly low. The character of the surface of the metal has a very considerable influence on the friction, and it will probably be found that the harder and denser the material, the less will be the friction. Chilled cast-iron sled shoes, for example, are commonly believed to run much more easily than ordinary steel shoes.

DERAILING SWITCHES AT INTERLOCKED CROSSINGS.

At the meeting of the Railway Signaling Club, held in Chicago on March 11, an interesting discussion took place on the above topic as a result of the paper by Mr. Charles Dunham (Illinois Central R. R.), which was published in last week's issue. We present an abstract of the discussion as follows:

Mr. Dunham stated that the time-lock is applicable for any practicable distance between the home and distant signals, up to 2,000 ft. The lock is applied to each home signal lever governing a high-speed route, and while the signal can be thrown to danger at any time, the derail cannot be opened until a given period after the signal has been thrown. It is not a substitute for electric locking, nor is it recommended for tracks for switching movements, or for crossings or junctions, where the traffic is heavy. It is specially adapted for isolated or moderately busy crossings and junctions, and where the cost of electric locking is considered too great.

Mr. W. H. Elliott (C., M. & St. P. Ry.), thought it objectionable to permit derails to be opened after a certain time. With electric locking, the clearing of a home signal drops the lock for the derail of that route, and the lock cannot be released until a train has passed the crossing, unless the signalman operates the special release provided for the emergency of failure of the apparatus. If a signalman does this and no failure is found by the repairman, a check is kept on him for a time to see if he is in the habit of using the release improperly. He doubted if the cost of maintenance of the electric was as great as had been assumed, although he had no figures as to this cost independent of the maintenance of the interlocking. Where the signalman is not required to be an operator he can easily be taught to look out for broken wires and to repair batteries. The insulation at joints must be well maintained, and for this purpose they should be oiled about once in two months; the use of black oil will raise the resistance from 0.5 to 15 ohms. He did not approve of the suggestion to operate the derail lock from the distant signal lever, as the home signal is the one which gives an engineman the right to pass over the crossing. Several cases have occurred where the man having once seen the signal clear, has failed to see it changed to "stop." As to derailments at low speed, he thought the damage done depended much more upon the length of train than upon the speed.

One member suggested that the derail should be locked by the train passing the distant signal and released by its passing the home signal, but it was pointed out that a slow train stopping between the signals would make it impossible to clear the opposing route for a fast train. Mr. Vernon (N. Y., N. H. & H. R. R.) suggested the use of two home signals, and Mr. Cade (Standard Railroad Signal Co.) thought this a good suggestion, introducing the same principle as the overlap in block signaling. If a man passes the rear home at danger he does not at once pay the penalty, but has another chance to prevent derailment. He thought railways had been liberal in providing derails, because they could not rely upon the men obeying the signals, but with the better discipline of the present day, he thought some of the expense might better be devoted to additional interlocking plants. Mr. Elliott, however, did not approve of such a practice, and investigation has shown that many more accidents have been averted by the use of derails than have been caused by their misuse.

THE STONE ARCH BRIDGE over the Neshaminy Creek, near Edison, Bucks Co., Pa., was built in 1801 and is thus described in the Doylestown "Republican." It includes seven arches and two abutments; the center arch is 30 ft. span, and the three arches on each side are, respectively, 27, 23 and 20 ft. span. The piers are 5 ft. thick and the outside width of the bridge is 25 ft. The bridge was authorized Nov. 23, 1799; it was finished on Dec. 8, 1801, and cost $13,476.16. A previous wooden bridge was built at this place in 1764, at a cost of £210, raised by subscription among the nearby residents.

A STREET RAILWAY CONVENTION is to be held in London, England, July 1 to 4. It will comprise the biennial meeting of the International Tramways Union, and a special exhibition arranged by the Tramways and Light Railways Association, of England. The offices of the "Union" are at Brussels, Belgium; Mr. L. Janssen, of the Brussels Tramway Co., is President, and Mr. P. Serstevens is Secretary. A report of the proceedings of the last meeting, at Paris, in 1900, was given in our issue of Nov. 15, 1900.

AN INTERNATIONAL MOTOR-BOAT EXHIBITION is to be opened on June 1 at Wannsee, a watering place on the River Havel, near Berlin, Germany. The exhibits will cover the construction, care and use of boats, launches, yachts and other craft of moderate tonnage propelled by gas, gasoline, electric or steam motors. The enterprise is under the auspices of the Middle European Motor-Carriage Association, No. 1 Universitäts Strasse, Berlin, Germany.

A JAPANESE NATIONAL INDUSTRIAL EXPOSITION is to be held at Osaka, Japan, from March 1 to July 31, 1903. A special feature will be a building for the exhibition of samples of articles produced or manufactured in foreign countries. While the acknowledged object of this exhibit is the opportunity afforded to Japanese manufacturers of studying the latest products of Western invention, with a view of improving Japanese industries, it is claimed that it offers foreign manufacturers a rare opportunity for exploiting the rapidly developing markets of the whole Far East. Full information is published by the Imperial Department of Agriculture and Commerce, Tokio, Japan.

A NEW CHART OF LINES OF EQUAL MAGNETIC declination and of equal annual changes in the United States, for 1902, has been issued by the U. S. Coast and Geodetic Survey, Mr. O. H. Tittmann, Superintendent. The isogonic lines are given for every degree, and are based on all known observations up to Jan. 1, 1902. On the broad zero-line shown, the magnetic needle points true north and south. The lines of equal annual change vary from 1° to 5', and pass through all places where the annual change is of the same amount.

THE DIAMOND SHOAL LIGHTHOUSE proposition made by Mr. Albert F. Ellis, of Boston, Mass., has been reported against by the Lighthouse Board. Mr. Ellis offered to erect a lighthouse on these shifting sands for $550,000, with the proviso that unless it was a success no payment was to be made. The grounds of rejection were: That to accept such a proposition would be against the policy of the board in the matter of competition for contracts; and Mr. Ellis offered no guarantee for the maintenance of the light for any definite time. The North Carolina Senators, however, still advocate the plan submitted by Mr. Ellis, and he is to explain to the Senate Committee his proposed structure.

THE PRODUCT OF OUR MANUFACTURING and mechanical industries in 1900 amounted in value to $13,040,013,638, says a report just issued by the U. S. Census Bureau. This is an increase of $3,067,576,355, or 39.1% over the gross value of the products of 1890. In 1880 this gross product was only $5,369,579,191. These gross values do not represent the final values of the manufactured products of the country, as a constant duplication of values occurs in the tables, as the finished products of one branch of industry become the materials of other establishments. It does, however, fairly represent the commercial transactions involved. The apparent value of products per wage-earner has increased from $1,065 in 1850 to $2,451 in 1900.

BOOK REVIEWS.

THE MECHANICS OF ENGINEERING.—Vol. I.: Kinematics, Statics, Kinetics, Statics of Rigid Bodies and of Elastic Solids. By A. Jay DuBois, C. E., Ph.D., Professor of Civil Engineering in the Sheffield Scientific School of Yale University. First Edition. First Thousand. New York: John Wiley & Sons. Cloth; 8 × 11 ins.; pp. 634. $7.50.

This work is presented by the author as the first volume of a series dealing with the applications of mechanics to engineering problems. The well-known treatise on "Stresses in Framed Structures" by Professor DuBois is to be revised to form the second volume of the series. The author has made a profuse use of examples from engineering practice throughout this book, designed to familiarize the student with the application of the abstract mathematical principles to concrete cases. In the hands of the right teacher this feature will be of value; but the student needs in every case to be cautioned again and again that the mathematical solution of a practical problem needs always to be modified by the use of sound common sense, a more useful asset to the engineer than a high degre of proficiency in mathematical analysis.

SHOP AND ROAD TESTING OF DYNAMOS AND MOTORS.—A Practical Manual for the Testing Floor, the Car Barn and the Road. By Eugene C. Parham, M. E., Formerly Electrician Steel Motor Co., Johnstown, Pa., and John C. Shedd, Ph.D., Professor of Physics, Colorado College. New York: Electrical World and Engineer. Cloth; 6 × 8 ins.; pp. 627, with 207 figures. $2.50.

This is the second edition of this book, the first having been published in 1897. Part I. is devoted to an elementary explanation of such principles of electricity and magnetism as are essential to intelligent work by the testing engineer or inspector. Next the testing instruments in common use are explained, and in Part III. the details of practical dynamo and motor testing are described. To the present edition two chapters have been added describing tests of electric street car equipment. The book is thoroughly practical and at the same time sound and accurate in its presentation of electrical theory.

PRACTICAL MARINE ENGINEERING for Marine Engineers and Students, with Aids to Applicants for Marine Engineers' Licenses. By Wm. F. Durand, Professor of Marine Engineering, Cornell University, New York. "Marine Engineering." Cloth; 6 × 9 ins.; pp. 706. $5.

There are a good many technical books placed on the market with the word "Practical" attached to their titles which are found on examination to be anything but practical. The present work, we are pleased to say, does not belong to this class. It is a plain, elementary manual, prepared for the use of the man who would fit himself for responsible service in the engine room of a vessel, and it is far and away the most successful and useful book in this field we have ever seen. A considerable part of the book will be found valuable also by the general student of marine engineering who is fitting himself for work as a designer of vessels or engines; but it is for the first-named class that the book was particularly written.

Most text-book writers who attempt to describe engineering practice fail to describe present-day methods and appliances. In this respect Professor Durand deserves great credit. He has kept in remarkably close touch with the recent progress in the ship-yard and the engine room and the result is evident in the character of his work.

The concluding portion of the book contains an elementary treatise on arithmetic, mechanics, mensuration and physics designed for engineers desiring by self study to fit themselves to pass examinations required to obtain licenses.

A SEVERE TEST OF A DAM.

During the floods which occurred at the beginning of March the great dam at Elmhurst, near Scranton, Pa., received a heavy visitation of a somewhat peculiar character.

The Elmhurst dam, known formerly as the Dunning's dam, was built in the late '80's on the plans and under the supervision of Mr. E. Sherman Gould, M. Am. Soc. C. E., then engineer to the Scranton Gas & Water Co. It stored originally some 12,000,000,000 gallons, which was afterwards increased by an addition to its height to about 1,350,000,000 gallons. The work was fully described in a paper presented by Mr. Gould before the American Society of Civil Engineers, Oct. 17, 1894.* It is a composite structure of masonry and earth. A peculiarity of this dam is that, in order to secure the desired amount of storage, it was necessary to raise the crest 12 ft. above the track of the Delaware, Lackawanna & Western R. R., which ran alongside the valley of Roaring Brook, across which the dam was built. This necessitated building a return wall, forming a continuation of the main dam, parallel to the [illegible] and running 1,200 ft. up the valley, until the [illegible] grade of the road carried it above the flow [illegible] of the reservoir. As there was a good deal [illegible] on this side of the valley, the wall was put [illegible] left a foot lower than any part of the dam [illegible] other side, so that if from any cause the [illegible] should fail to carry all the water coming [illegible] the overflow might take place on the side [illegible] rock was found.

On Friday, Feb. 28, 1902, as a heavy [illegible] seemed imminent, and the reservoir was full [illegible] active measures were taken to prepare for it. The water was drawn down by means of the [illegible] blow-off, and at 9.30 a. m. of that day, [illegible] 12 ft. 6 ins. below the top of the spillway, and [illegible] ice was cut away for several feet behind it. [illegible] the expected freshet occurred, the water rose [illegible] idly, and on the following day, Saturday, March 1, at 3 30 a. m., was on the point of flowing over. But the ice behind the dam, broken into sheets 50 ft. square, and stated to have been 36 ins. thick, became jammed across the spillway opening, [illegible]

FLOOD AT THE ELMHURST DAM OF THE SCRANTON GAS & WATER CO.

(From a photograph taken Saturday, March 1, 1902, at 11 a. m.)

ing it, as a correspondent writes, as effectually as a stone wall would have done, in spite of all efforts to keep it clear.

The water, denied its natural egress, now poured over the whole 1,200-ft. length of the return wall, flooding the D., L. & W. track, and washing out a portion of it below the dam. Dynamite was at once resorted to, and the spillway was cleared about 2 p. m. of Saturday, March 1.

All possible expedients to avert damage seem to have been resorted to throughout, with intelligence, promptitude and decision. No fears were entertained as to the safety of the dam itself, and sensational newspaper reports to the contrary were fictitious.

The accompanying illustration from a photograph shows the spillway and the discharge over the return wall when the freshet was nearly at its height. The photograph was taken on Saturday, at 11 a. m., three hours before the spillway was cleared. The man shown standing in a rather precarious position on the spillway is in the act of placing dynamite to break up the ice.

*Eng. News, Oct. 18, 1894.

COMMITTEE REPORTS OF THE AMERICAN RAILWAY ENGINEERING & MAINTENANCE-OF-WAY ASSOCIATION.

The third annual convention of this association was held at Chicago on March 18, 19 and 20, and a report of the proceedings will be given in our next issue. Below we present abstracts of some of the reports submitted by the standing committees of the association:

Ballasting.

MATERIAL.

A material suitable to perform the functions of ballast must be in small, angular pieces, hard enough to resist the load and tamping without material injury; it must be relatively free from decay and unaffected by weather; it must permit of easy handling and provide good drainage. The materials which practice has found to fulfil the conditions required, more or less perfectly, are broken stone, gravel, coarse sand, burnt clay, partially disintegrated

rock, slag, cinders, and various products resulting from the preparation of ores, such as chatts, Joplin gravel, etc.

STONE.—The varieties of stone usually considered suitable and commonly obtainable at reasonable cost, are trap rock, granite, magnesium limestone, hard limestone, hard, siliceous limestone having over 95% silica. These materials, after being crushed into approximately cubical pieces of from ½ to 1½ ins. diameter, probably give the best results. In practice we find a maximum of from 1½ to 3 ins. allowed.

GRAVEL.—Gravel to make good ballast must be composed of firm particles that will not rapidly decay, and of sizes running from coarse sand to 1½ ins. diameter. It must be sufficiently free from clay and soil to drain well. Gravel containing boulders, round pebbles and considerable clay can be made into first-class gravel ballast by passing through washer and crusher, the larger boulders being crushed into small irregular masses, giving a superior holding quality on the tie. The washing will make the ballast drain, so that it will not churn in wet weather.

COARSE SAND.—Where the particles are angular this may be used for ballast, but usually washes easily, is apt to blow in dry weather, and is exceedingly dusty under fast trains, unless it is that peculiar quality of sand which seems to cement together and will stand at a very high angle of repose.

BURNT CLAY.—Burnt clay has been used with varying results, depending on the quality of the material burned and the manner of burning. Clay containing little sand and a sufficient quantity of fluxing material to produce a semivitreous mass has undoubtedly made a fairly good ballast. It drains well and makes good track. On the other hand, much burnt clay ballast has been put into track which has been too soft to stand the load and has disintegrated under the action of the weather.

PARTIALLY DISINTEGRATED ROCK.—In many parts of the country there are deposits of rock that have become partially disintegrated through ages which contain much hard material that will form the main body for ballast, while the other material is sand-like or of a nature that will not clog the drainage, and such partially disintegrated rock, in some instances, will form an excellent ballast which promises to be very durable.

SLAG.—Blast-furnace slag, containing a small excess of lime and being of a glassy nature, when broken up under the track, fulfils the requirements of ballast to a very large degree. If a large excess of free lime is present, it soon becomes too soft to hold the load, becomes concreted under the ties and churns in wet weather. Slag-ballasted track usually requires a lift of 2 or 3 ins. and to be surfaced out of face at intervals of from two to six years, depending on the hardness of the slag and the amount of traffic. Slag composed almost exclusively of hard, glassy pieces approaches closely to the quality of rock ballast; on the other hand, slag with a large amount of free lime is inferior to reasonable good gravel.

CINDERS.—Engine cinders find a place as ballast, particularly on soft subgrades and branch lines, and while they drain well, they usually do not hold up well under extremely heavy traffic, and in some cases these cinders contain materials which, acting on the tie, shorten its life.

CHATTS, JOPLIN GRAVEL, ETC.—These materials make a ballast which holds its surface well, but not always its line. They are usually dusty under speeds exceeding 45 miles an hour. They are extremely easy to work, are not affected by wet weather, keep down weeds and make excellent ballast in yards and on roads where there is not a heavy passenger service at speeds of 50 miles per hour and upward.

PREPARING SUBGRADE.

It is of very considerable importance that the subgrade or roadbed should be of suitable cross-section and material before ballast is applied. In ballasting, we have two kinds of conditions: 1, where new track is to be laid and ballasted, and 2, old track which may have had more or less material which has been used as ballast in the past. The requirements of the subgrade are that it should drain freely and be of sufficient sustaining power to carry the traffic without appreciable settlement when the load shall have been distributed with some degree of uniformity over a strip about 2 ft. wider than the length of the ties. In practice, it is sometimes necessary to apply something which might be called "sub-ballast." If the material of the roadbed is such that it will not support stone ballast, or any other coarse ballast, without its becoming imbedded in it and causing the mud to work up through the ballast and allowing the ballast to be continually settling, some intermediate material must first be placed on the roadbed, care being taken that any impervious material is of such contour that the water can drain freely from its top. Usually cinders, gravel or screenings will answer for this purpose; sometimes coarse rock, from 10 to 30 lbs. in weight, will perform this function better.

DEPTH OF BALLAST.

This is determined by several conditions. The conditions usually ruling are that the load shall be distributed by means of the ballast so that the load on the ties distributed to any part of the subgrade shall not be above its sustaining power. On extremely hard subgrade, the depth required is that which will allow of such distribution of the load on the ballast and such uniformity of material under the tie that there will be no crushing of the ballast itself, or no danger of springing or breaking the tie. Material which will stand at approximately a 1 to 1 slope, like crushed stone, will distribute the load with reasonable uniformity at a depth not less than the distance between the bearing surfaces of the ties; with other material, which will stand at a lesser angle, a greater depth would be required. It is doubtful if, in practice, a less distance than 8 ins. under the ties can reasonably fulfil the above conditions, and we believe that it is highly probable that 12 ins. of depth usually fulfils these conditions within a reasonable degree, and would recommend that 8 ins. under the ties be the minimum depth for any class of ballast.

BALLAST CROSS-SECTION.

STONE.—Depth below tie, 8 to 12 ins.; top surface at top of tie; slope, from top of tie at the ends to subgrade, at the rate of 1¼ to 1 or 1½ to 1.

GRAVEL.—For gravel containing an appreciable amount of clay and not too easily drained under all conditions—depth under tie, 8 to 12 ins.; top of ballast between rails, top of tie; top of ballast at end of tie, bottom of tie; slope to subgrade, 2 to 1. In our opinion, there is no one cross-section which can be used for all classes of gravel ballast to advantage. In gravel ballast, which drains very poorly, it will be necessary to leave the end of the tie open to avoid churning. As the gravel becomes more and more pervious, lighter and has less coherent parts, the top of the ballast may be brought up on the end of the tie, until, in light sand ballast having usually worn particles and draining very freely, it will be necessary to bring it above the top of the tie at the end, and even carry the top of the ballast some distance beyond the end of the tie before starting the slope. In some ballasts of this nature, better results are obtained by raising the top of the ballast between the rails above the top of the tie. For crushed and washed gravel, the cross-section for stone may frequently be used.

CHATTS, DISINTEGRATED STONE AND COARSE SAND.—Where these drain thoroughly: depth of ballast below tie, 8 to 12 ins.; top of ballast, 1 to 2 ins. above top of tie; top of slope, 6 ins. beyond end of tie and even with the end; slope, 1¼ to 1 to subgrade. We believe that practice has demonstrated that in this class of ballast, particularly the lighter varieties, the tie must be buried in the ballast, or it will blow out, and only under these conditions, where it becomes self-tamping, can the line and surface be satisfactorily maintained. Track put up on this light ballast is frequently knocked out of line, unless the tie is buried and the slope begins some distance outside of the end of the tie.

There are, however, some deposits of partially disintegrated limestone, flint and granite, which, in their more solid deposits, can best be given a cross-section closely approximating that of crushed stone. In all these cross-sections, the variations are in that portion of the cross-section representing the top of the ballast from the outside of the rail to the subgrade at the outer end of the slope. The conditions which determine the proper figure of this portion of the cross-section are more than anything else dependent on the draining qualities of the material used; second, as to whether the pieces are angular, or jagged, or more or less round and smooth; next, upon the specific gravity of the material; next, the coarseness or fineness of the material. Hard, heavy and angular pieces will soon imbed themselves into the surface of the tie; they will hold the tie firmly, and it is only necessary to carry the natural slope of the side of this ballast a short distance beyond the end of the tie to insure a sustaining power to the very end of the tie. With material which drains poorly, the ballast must be left open at the end of the tie, or the tie will churn itself down. When the material is fine, light and drains well, there is not sufficient hold on the tie to keep it in line without having considerable ballast at the end of the tie carried out to some considerable distance, and, in some cases, there is a churning in which the air acts in the same manner as does water in ordinary cases of churning in wet weather. In such cases the light material is thrown up and out at the sides of the track, and until the tie is buried sufficiently to catch this material and cause it to fall back again and other material to run in and take its place, the surface of such light ballast is soon destroyed.

E. Holbrook, K. C. So. Ry.; F. A. Molitor, Choctaw, Ok. & G. Ry.; H. U. Wallace, Ill. Cen. Ry.; C. B. Hoyt, N. Y., C. & St. L. Ry.; John V. Hanna, St. L. & S. F. R. R.

Ties.

Two studies which will be practically continuous in interest and importance are "Timber Supply and Culture," and "Timber Preservation," and these have been touched upon in the present report. Statistical information, too, is very important to enable us to draw conclusions. We have continued to report such information in that line as has been sent us, but have not attempted to analyze the results in much detail. Specifications for ties are being studied with a view to making recommendations.

TIMBER SUPPLY.

In response to a circular letter of inquiry, replies were received from about 80 roads, representing 70,000 miles. It was the intention to ask questions which members could answer from general knowledge, expecting that from these general answers, by comparison, fairly correct conclusions as to the general facts could be drawn. The questions as to the supplies of timber remaining are, of course and avowedly, estimates.

The replies indicate that generally there has been no change, or but very little, in the specifications under which ties are bought. As to the question: "Have you changed the sources of your supply?" one-third of the replies were in the affirmative, and two-thirds in the negative. The figures have been carefully studied and the facts summarized are as follows:

Eighteen roads (17,500 miles) now secure all their ties of the kind now used from along their own lines, and have a supply in sight for the next ten years. On half of this mileage pine ties are the standard.

Five roads (4,500 miles) have in the past been able to supply all their own needs, but can continue to do so for less than ten years.

Seven roads (7,100 miles) can supply 50% or more of their own needs for from two or three years on indefinitely.

Eleven roads (19,000 miles) can furnish more than 10%, but less than 50%.

Twenty-one roads (14,500 miles) can supply none or less than 10%.

As regards supplies of inferior woods, there were 13 roads (8,000 miles) reporting none available. All the rest reported supplies sufficient for from 3 to 30 years.

Geographically considered the figures above are based on replies received representing a mileage of 13,000 in eastern Canada, the New England and Middle states; 10,000 in southern Atlantic; 33,000 in the Middle West and Southern states; 6,000 in the Western states.

Besides the roads represented in the figures above, reports were received from the Southern Pacific, Atchison, Topeka & Santa Fe, and the Colorado & Southern. The first two roads are already using treated ties very largely and consequently using inferior timbers; and it did not seem best to include them in the summaries. The Atchison, Topeka & Santa Fe Ry. reported that it had changed the source of supply during the past two years, in that while formerly using oak ties for their lines in Kansas, Illinois and Iowa, it is now using treated pine ties; and in consequence of the treatment it did not rate as inferior woods those materials which are usually so considered. The Colorado & Southern will change this season from untreated mountain pine (with a life of only three years) to the same material treated, which will be used exclusively.

PRESERVING METHODS.

A review of what American railways have done since 1885 towards tie preservation was given in the last report. Since then the Atchison, Topeka & Santa Fe Ry. has compiled a record in detail of treated pine ties which shows the following average life of ties removed on seven divisions: removed in 1897, average life 10.70 years; in 1898, 11.06 years; in 1899, 11.11 years; in 1900, 11.28 years.

On the Chicago, Rock Island & Pacific Ry. lines east of the Missouri River, the average life figures up 10.57 years, and the reports on the lines west of the Missouri River indicate an average life one year longer. Of one lot of 21,850 treated ties laid on this part of the line in 1885, of which special record has been kept, 1,610 ties (12%) were still in the track in 1900, after 15 years' exposure, but 1,604 came out in 1901.

As stated in the last report, the Southern Pacific Co. has adopted from the beginning a system of records for treated ties much superior to that of any other road. It has compiled statements of renewals to June 30, 1901, from which a table has been computed into renewal percentages of the ties originally treated and laid each year. On this line, much as on the Atchison, Topeka & Santa Fe, the best results have been obtained in the more arid regions. For the whole road the average life of the ties treated in 1887 figures up 7.89 years, and those of 1888 average 9.73 years, but the subsequent years, except perhaps 1898, promise to make a much better showing.

The Pennsylvania Lines West of Pittsburg have laid since 1896 over 150,000 ties treated by the zinc-tannin process. These ties have yet had too brief an exposure to inquire into the results, but they are here on record to serve an inquiry into the average life of these various kinds of treated wood hereafter. This road, however, inaugurated an experiment in 1892, by laying 200 hemlock and 200 tamarack ties, treated by the zinc-tannin process, alongside of an equal number of untreated white oak ties. The results up to July 3, 1901 (9 years), were as follows: in stone ballast, 25% of hemlock and 40% of white oak renewed; in gravel ballast, 78.5% of tamarack and 50.1% of white oak renewed. This indicates that hemlock is preferable to tamarack for treatment and that stone ballast is preferable to gravel ballast for treated ties.

The Chicago & Eastern Illinois R. R., the Chicago, Burlington & Quincy R. R., the Great Northern Ry., the Missouri, Kansas & Texas Ry., and some other lines, are also having ties treated; but their experience is yet too recent to be put on record at this time.

Too much stress cannot be laid upon the importance of keeping full records; not only in the track, but of the treatment at the works, to serve as a basis for future improvement of processes, or of change of process, for plants can easily be altered. Better economical results will thus be obtained, although, perhaps, at greater first cost.

Ties last much longer abroad than they do in the United States. An inquiry into European methods and results of tie preservation has been carried on since 1892 by Mr. V. Herzenstein, civil engineer, of St. Petersburg, Russia, who was appointed reporter thereon by the International Commission of the Railway Congress. An elaborate report was submitted to the meeting of September 25, 1900, which is published in the Bulletin of the International Railway Congress for July, 1901. The gist of the whole report is fairly summed up in the following quotations:

> The managements which treat their ties recognize, as we have already stated, that the best process, as far as the life of the tie is concerned, is creosoting (or the Blyth's process properly carried out); but they all mention that it is necessary to use a heavy oil (crude creosote), which is rich in antiseptic substances, such as carbolic acid, naphthalene, etc. Several managements (Russian lines) express the opinion that the treatment with zinc-chloride is the cheapest process for insuring that fir and pine ties should have a reasonable length of life. The French State Railway and several other railways prefer to treat ties with an emulsion of zinc-chloride solution and creosote; this process seems to have a future before it, particularly in the case of sap wood, which is very absorbent. The information supplied by the different managements shows that the best process on the whole is creosoting; the average life (which we may perhaps fairly consider as the average life for all railways) of creosoted ties amounts to:

	Main Line.	Sidings.	Total.
Creosoted pine.....	15 years.	5 years.	20 years.
Creosoted oak	18 "	7 "	25 "
Creosoted beech.....	20 "	10 "	30 "

> This shows that beech is a very good wood for ties and that we are justified in considering the beech tie as the tie of the future.

An examination of the individual reports of the railways tabulated shows that a number of them have failed to realize the above quoted average life with creosote, and that the best results coincide with the highest cost of treatment. Where timber is still comparatively cheap, inferior processes will be resorted to. For the zinc-chloride treatment one Prussian road reports 15 years average life for treated pine, one Austrian road reports 12 to 16 years, and another 19.6 years; one Danish road reports 12 years, and the Dutch Ry. reports 15 years. All of these are for pine. The average lives show better for oak and worse for beech than the above. The Russian roads, which took up the process later, seem to have obtained very inferior results. One road reports 8 years, another 7 years, and a third 10 years as the average life of pine treated with zinc-chloride. Many of the Russian roads using the process omit to state the results, possibly because their experience is too recent. Ties in that country are still cheap, pine ties being reported by various lines as costing untreated, from 12.4 to 44.2 cts. each, and oak ties from 36.2 to 64.8 cts. each.

Mr. Herzenstein calls attention in other parts of this report to the Rütgers or zinc-creosote process as likely to prove effective for cheap ties. The Imperial Prussian Railways, which have had the longest experience with this process, did not answer his circulars. Four other roads did, but do not state the average life. The French State Railway, however, estimates that zinc-creosote preserves the sleepers about 25% longer than straight zinc-chloride.

In a discussion of tie preservation by the French Society of Civil Engineers in July, 1901, it was stated by a member, who advocated straight creosoting, that he had made an examination during the preceding month of 17,375 sleepers treated with zinc-creosote by Rütgers and laid in 1888. Some 84% were yet in the track after 13 years' exposure, while of a lot treated by another contractor by the same process (nominally) no less than 50% were rotten after an exposure of 6 years.

It is understood that one of the plants in the United States is about to experiment with the zinc-creosote process; having succeeded, after a year's delay, in procuring suitable tar-oil.

One tie-treating plant has been shut down, one has been moved, and two have been built in the United States during 1901. They now stand as follows:

Location.	Year built.	Owner.	Process.	Kinds of wood.	No. retorts.	Estimated Capacity ties per annum.
Lowell, Mass.	1848	Locks & Canal Co.	Kyanizing	Various	2	30,000
Las Vegas, N. M.	1885	A., T. & S. Fe Ry.	Zinc-chloride	Pine	3	500,000
Bellemont, Ariz.	1898	A., T. & S. Fe Ry.	Zinc-chloride	Pine	2	350,000
Chicago, Ill.	1886	Chi. Tie Preserving Co.	Zinc-tannin	Hemlock	4	500,000
Mt. Vernon, Ill.	1899	Chi. Tie Preserving Co.	"	Black oak	1	200,000
Somerville, Tex.	1897	Tex. Tie & Lumber Co.	"	Pine, etc.	6	2,000,000
Kalispell, Mont.	1901	Great Northern Ry.	"	Pine fir	4	1,200,000
Houston, Tex.	1891	Southern Pacific Co.	Burnettizing	Pine fir	5	1,500,000
Greenville, Tex.	1901	Mo., Kan. & Tex. Ry.	Zinc-tannin	Pine gum	3	900,000
Calif. and Oregon	1894	Southern Pacific Co.	Burnettizing	Pine fir	2	1,000,000
Oakland, Cal.	1889	Southern Pacific Co.	Creosoting	Pine, etc.	2	1,000,000
Sheridan, Wyo.	1899	C., B. & Q. Ry.	Burnettizing	"	2	500,000
Beaumont, Tex.	1897	Intl. Creo. & Cons Co.	Various	"	1	500,000
Perth Amboy, N J.	1890	U. S. Wood Preserving Co.	Creo resin	"	4	1,200,000
Brooklyn, N Y.	1878	Eppinger & Russell.	Creosoting	"	4	800,000
Norfolk, Va.	1896	Nor. Creosoting Co.	"	"	4	900,000
W. Pascagoula, La.	1876	L. & N. R. R.	"	"	2	400,000

Under the auspices of the United States Department of Agriculture an experiment was inaugurated in 1901 to test the relative merits of different methods of treating ties of various kinds of timber. For this purpose about 5,850 ties have been donated. Of these some 4,900 have been treated gratis at Chicago, at Somerville, Texas, and at Beaumont, Texas, by the zinc-tannin, the zinc-chloride, the Allardyce and the Hasselmann processes; also with Beaumont petroleum, and zinc-chloride, with carbolite and with spirittine. The most noxious place which could be found has been selected, about 75 miles east of Somerville, on the Montgomery branch of the Gulf, Colorado & Santa Fe Railway in Texas, at a spot where unprepared pine ties generally decay in 12 to 14 months, and where, in consequence of the bad drainage, heavy rainfall and warm temperature ties treated with zinc-chloride have decayed in 2 to 4 years. The results are to be watched and reported upon year by year by the special agents of the Bureau of Forestry, Department of Agriculture. Messrs. Hermann von Schrenk and Gellert Alleman are the special agents who hve managed the arrangement and the marking of these experimental ties with dating and identification nails.

Professor von Schrenk visited Europe in the summer of 1901 to investigate timber preservation and has made an elaborate report to the United States Department of Agriculture. The choice at present lies between these various processes:

1. Creosoting—Injection of heavy tar-oil, rich in antiseptics.
2. Creo-resinate process—Creosote, resin and formaldehyde.
3. Water-creosote process—Emulsion of creosote and water.
4. Kyanizing—Injection of corrosive sublimate.
5. Burnettizing—Injection of chloride of zinc alone.
6. Zinc-tannin—Chloride of zinc, followed by glue and by tannin.
7. Zinc-creosote—Emulsion of chloride of zinc and creosote.
8. Allardyce process—Injection of chloride of zinc, followed by creosote.
9. Hasselmann process—Boiling in sulphates of iron, copper, etc.

Now that American railways are beginning to treat their ties we may expect a new crop of suggestions and processes. It may be well to experiment on a small scale with the more plausible of them, so that five or ten years hence we can judge of the probable results. Especially is this the case with petroleum, a home product, some varieties of which are now very cheap. It is not an antiseptic, but possibly may be rendered so by the addition of other substances. It is understood that the Russian chemists have been endeavoring to do this, but have not made a success as yet.

STATISTICS.

Many of the members are yet unable to furnish statistics relative to ties, but it is hoped that in course of time all will be keeping their records on the same basis. Blanks were sent by the Secretary to 187 members, and answers were received from 53, or 28%. Of the replies, 14 (26%) stated that no information could be given for lack of proper records; 39 (73%) filled in some of the forms. One of the first duties of the association in connection with this subject is to decide what will be the standard form of blanks for keeping records, so that the information will be presented in the same manner each year.

E. B. Cushing, So. Pac. Ry.; W. C. Cushing, Pa. Lines; O. Chanute, Cons. Engr.; W. W. Curtis, Cons. Engr.; J. B. Berry, U. P. Ry.; Wm. Archer, B. & O. S. W. Ry.; C. C. Mallard, So. Pac. Ry.; E. E. Hart, N. Y., C. & St. L. Ry.; J. S. Nelson, A. G. S. Ry.

REPAIRING A STEEL CHIMNEY IN AN OFFICE BUILDING.

A novel plan for repairing a steel flue was successfully employed recently in a New York city office building. The chimney flue of the American Surety Building, a 21-story structure, is a steel stack of 45 ins. diameter, with a thickness of metal of ½-in. to ¼-in., and extending from the basement to the roof. It was held at each level by a frame of 5-in. channels riveted to the main floor beams. These frames were intended simply as guides, the stack being designed to be self-supporting. The shell jammed in these guides, however, and the expansion and contraction due to temperature changes, acting together with the weight of the stack, forced the whole stack bodily downward some 3 ft., shearing off two rows of rivets in one of the bottom sections. The sheared rivets were ¾-in. in diameter, 96 in all, and that section of the stack telescoped into the adjacent sections. The channel frames at most of the floor levels were badly bent and twisted. The problem of raising the stack and properly supporting it was solved by Mr. John McKay, engineer for the owners, in the following manner:

A clamp ring of heavy bar iron was placed around the stack near the top and supported on the brick walls of the shaft. On Saturday night the fires under the boilers were drawn and a current of cold air was allowed to sweep up the stack. As the latter cooled it contracted upward from the bottom and began to draw the telescoped sections apart until a total motion of 6 ins. had been taken place. A clamp ring was then placed near the bottom and the top ring slacked off. On starting the fires the shaft expanded upward. Repeating the cooling operation gave another contraction and brought the bottom of the stack up to the desired position, though still lower than its original level. The sheared rivets were replaced by bolts, new holes for which were drilled; and this section was further supported by angle-iron stiffeners tap-bolted to the shell, relieving the load seam of much of the load. The channel frame at each floor had previously been removed and split collars, three in all, were placed at different levels to hold the stack in line. These collars were firmly clamped to the shell and at their ends were guided on vertical T-irons bolted to the floor beams of the building.

Thus the stack is now supported entirely at the bottom, and free vertical expansion and contraction is permitted. The job, which was commenced on Saturday night, was practically completed by Monday morning, so that the fires could be started again. The service of the building was therefore in no way interrupted.

THE NEW YORK RAPID TRANSIT RAILWAY.

VI.

Sewer Diversion.

SPECIAL CONSTRUCTION.—At a number of points along the line of the subway, where the crossing sewers to be diverted were of large size, or whefe the conditions were such that diversion was impracticable and the sewer had to be carried across the subway, special constructions were necessary. Perhaps the most notable instances of this special work were those at Canal St., 110th St. and 149th St. and Railroad Ave. These works were notable in themselves besides being notable as indicating the importance and size of some of the sewer diversion work required by the construction of the subway. Their description and illustration are, therefore, of twofold interest, and are given in some detail.

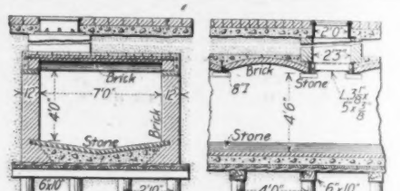


Fig. 19. Details of Box Sewer, Between Madison and South Streets.

At Canal St. the sewer intersected by the sub-

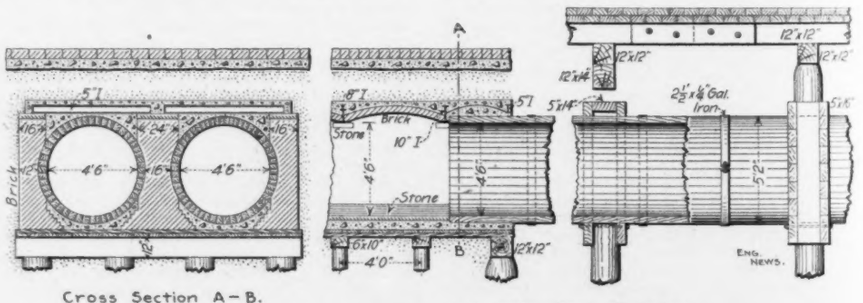


FIG. 20. DETAILS OF WOODEN STAVE PIPE OUTLET OF CANAL ST. SEWER.

way was a large main leading into the North River and draining an area of 180 acres in a very densely populated district. The plan adopted was the standard plan of considering the sewers on the two sides of the subway as separate systems. On the west side of the line, therefore, the old

...ain was tapped and continued in use, and on the ...st side a new main was constructed to empty ...to the East River. The work of constructing ...s new main is that which chiefly deserves men... Briefly stated, the new Canal St. main con-

FIG. 21. VIEW OF WOODEN STAVE PIPE OUTLET SEWER UNDER CONSTRUCTION.

sists of a 5½-ft. circular brick sewer from Canal St. to Leonard St.; of a 6½-ft. circular brick sewer from Leonard St. to Madison St.; of a box sewer from Madison St. to South St., and of two parallel circular wooden stave pipes from South St. to the pier end and outlet. All of the sewer was constructed in open cut except that portion under Chatham Square, which was built in tunnel.

The circular brick sewers call for brief mention only. They consist of two rings of brick, with a concrete base 6 ins. thick. The box sewer is shown in transverse and longitudinal section by Fig. 19. It consists of two parallel brick walls set on a pile and grillage foundation. Between these walls, at the bottom, is a floor of concrete, dished transversely and paved with stone. The roof consists of transverse I-beams spaced 4½ ft. apart, with brick arches sprung between them and filled above with concrete. The reason for adopting this form of section was the small depth of the grade below the street surface, which required a shallower section than could be had from a circular sewer of equal capacity. At its end the box sewer terminates in a brick bell mouth closed by a brick and concrete bulkhead, into which are built the inlet ends of the two 4½-ft. parallel circular wooden stave pipe sewers, which continue underneath the pier to an outlet near the end. Fig. 20 shows the connection of the box and wooden pipe sewers and the manner of supporting the pipe sewers on the pier piles. Fig. 21 is a view underneath the pier, showing one of the wooden pipe sewers completed and the other partly completed. In the partly conpleted pipe the manner of arranging the staves to break joints is clearly indicated.

The manner of constructing the sewer which is described above was to excavate a trench and build the conduit in it in the usual way, except that for a short section under Chatham Square tunneling was employed. Here, although the depth beneath the surface was only 30 ft., the heavy street traffic and the number of surface street railway tracks made it exceedingly important not to disturb the street surface. Tunneling was the only ready means of accomplishing the desired end, and it was accordingly resorted to. Although the section to be excavated was small—only 6½ ft.—the material penetrated, a very fine running sand, made the work rather difficult. To meet the difficulty, a decidedly novel and interesting mode of procedure was adopted, which is illustrated in the accompanying drawings, Fig. 22. Before referring in detail to these drawings, the novel devices which they show may well be concisely summarized. They are as follows: (1) The use of a system of interlocked poling boards to support the roof and the driving of these poling boards by ratchet jacks somewhat as a tunnel shield is driven in the shield system of tunneling; (2) the use of a cantilever beam to support the forward ends of the poling boards, and (3) the support of the sides and front of the excavation by lagging boards laid flat against and over strips of canvas, which are rolled down as the excavation progresses.

Turning now to Fig. 22, the drawing (a) shows a short longitudinal section of the tunnel at the working face, designed to indicate the method of jacking in the roof poling boards. Details of one of the poling boards are shown by the sketches (b). The 3×¼-in. lapping strip of steel, as shown by the drawing (c), laps half way over the adjacent board and closes the space between them. The drawing (c) also shows the arrangement of the roof poling boards in a horizontal plane and the rectangular cross-section of the excavation. Returning to drawing (a), the poling board is shown projecting back over the completed roof arch and supported on the transverse I-beam A, carried by a short section B of the side wall. In this position the board is ready to be thrust ahead into the sand. The power to perform this movement is supplied by a ratchet screw jack, but since this jack could not operate against the rear end of the board, it was placed at C, as shown, and acted upon the board by means of the lever D. The foot of the lever D rested upon the I-beam E, carried on the side wall masonry, and its opposite end was inserted in a hole in the underside of the poling board. The drawing (b) shows the arrangement of the holes in the poling board and the method of protecting them by iron plate guards.

By operating the jacks C, first one and then another of the poling boards was thrust ahead until all had been extended to their full length. In this fully extended position the downward pressure of the roof covering made necessary a support nearer the front ends of the boards than was afforded by the beam A, and this was provided by a transverse beam F, carried by the cantilever beam G, as shown by drawing (d). The drawing shows the manner of supporting and wedging down the cantilever beam quite clearly.

The method of lagging the face and sides of the excavation is easily traced from the four drawings of Fig. 22. The drawing (a) shows the two

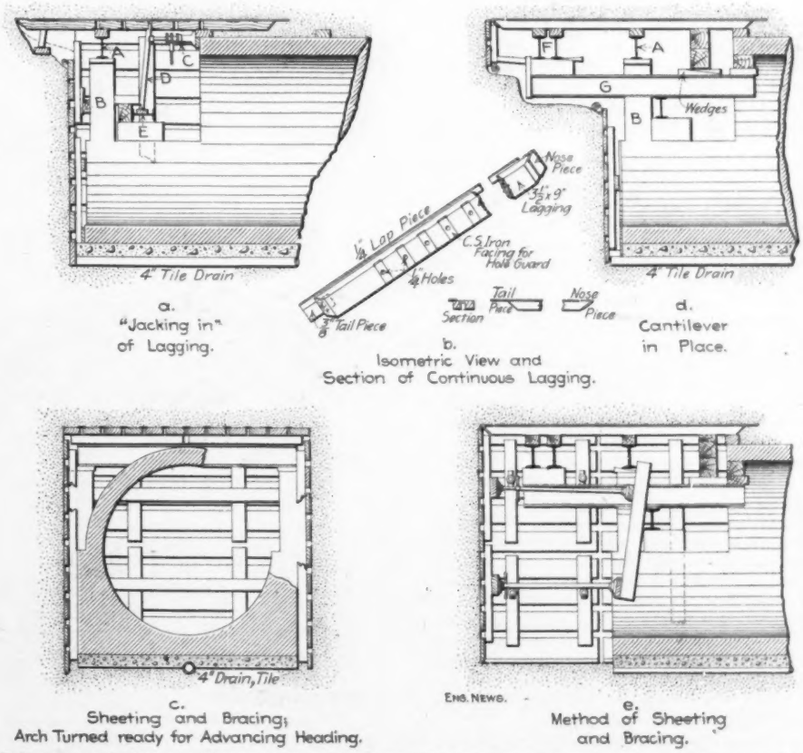


FIG. 22. SKETCHES SHOWING METHOD OF DRIVING SEWER TUNNEL UNDER CHATHAM SQUARE.

top face lagging boards removed and the canvas rolled down to permit the poling boards to be thrust ahead and the earth removed from just beneath them. In drawing (d) the poling boards

have been extended their full length, the third face lagging board has been removed and the excavation deepened, and the two top lagging boards of the new face have been placed with the canvas behind them. The removal of the fourth, fifth and succeeding face lagging boards followed, and as the excavation deepened the third, fourth and succeeding lagging boards of the new face were placed. The removal of the old side lagging boards and the placing of the new ones was accomplished in a similar manner to and simultaneously with the corresponding operations on the face lagging. The drawing (e) shows the excavation completed and the lagging in place and firmly braced, and drawing (c) shows the masonry of the sewer section. The excavation was completed, as shown by drawing (e), in lengths of from 1 ft. to 4¼ ft., and at the maximum rate of work about 12 ft. of finished sewer per week was completed.

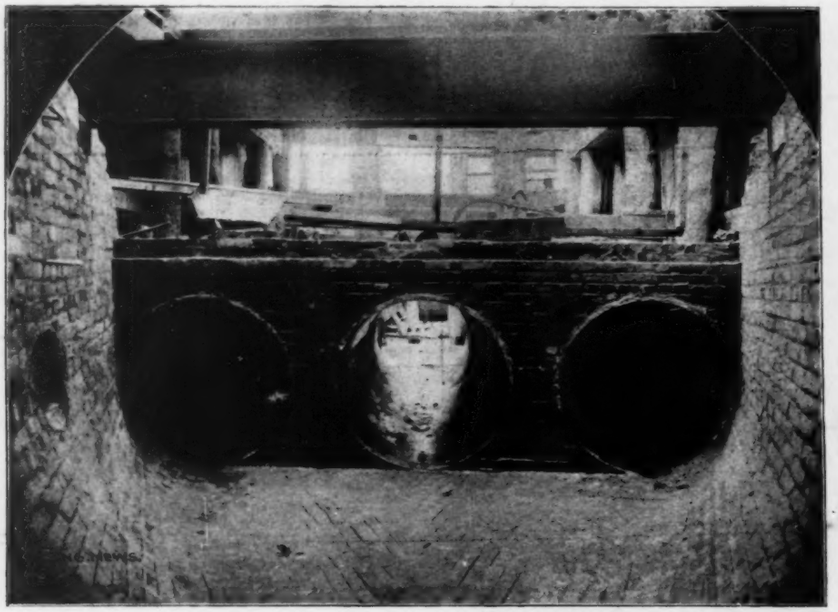


FIG. 23. VIEW SHOWING MANNER OF CARRYING 6½-FT. SEWER UNDER SUBWAY AT 110TH ST.

At 110th St. the sewer intersected by the subway was a circular brick structure 5 ft. 5 ins. in diameter, which received the drainage of about 124 acres. As constructed, the new sewer begins at 116th St., runs south along Lenox Ave., passing under the subway at a depth of 22 ft. below the street surface, and thence continues east along 110th St. to an intersection with an 8 × 12-ft. sewer at Fifth Ave. The points of most interesting construction are at the crossing under the subway at 110th St. and at the Fifth Ave. intersection.

Starting from 116th St., the sewer is a 5 ft. circular brick structure to the subway crossing at 110th St. Owing to the depth of the subway, the sewer could not be carried under it without changing its circular single tube form to one which would require less depth or head room. The plan adopted was to build a closed chamber on each side of the subway and to connect these chambers by three parallel 42-in. pipes underneath the floor of the subway. The 5 ft. sewer coming down Lenox Ave. empties into the west chamber, thence the sewage passes through the three 42-in. pipes to the east chamber, and from the east chamber a 6½-ft. circular brick sewer continues to the Fifth Ave. intersection. Fig. 23 is a view showing the construction at the crossing of the subway line.

At the Fifth Ave. intersection the 6½-ft. sewer from the 110th St. crossing intersects an 8 × 12-ft. sewer of horseshoe section. The sewers from the north and the south along Fifth Ave. also converge at this point. The plan adopted was to enlarge the 6½-ft. sewer into a bell mouth which embraced all the intersecting sewers. Fig. 24 shows the dimensions and construction of this bell mouth, and also the construction of the arch centers which were used. As will be seen, the bell mouth arch at its widest point had a span of 20¼ ft. Fig. 25 is a view inside the bell mouth.

The crossing at Railroad Ave. and 149th St. is remarkable for the siphon of unusual construction which carries the flow under the subway. Briefly described, the subway along 149th St. crosses Railroad Ave. at a depth below the surface of 35 ft. and intersects a brick sewer 6 ft. in diameter lying at a depth of 29.6 ft. below the surface. This sewer drains a large but rather sparsely populated area, so that its normal sewage flow is small and its storm flow is large. To divert this sewer would have necessitated such extensive alterations in it and in the connecting system it was decided to carry it by a siphon under the subway. This siphon was constructed, as shown in detail by Fig. 26, by cutting out the required length of old sewer under Railroad Ave. and installing a temporary iron pipe to carry the flow across the opening.

The unusual construction of the siphon is clearly shown by Fig. 26. The receiving chamber is at the left-hand end, and it is connected by a manhole with the street, as is also the discharge chamber at the opposite or right-hand end. It will be noted that the floor of the receiving chamber is divided by a sort of curved dam into two parts. From the space behind the dam a 14-in. cast-iron siphon passes under the subway to an outlet in the discharge chamber, and from the space in front of the dam two parallel 42-in. cast-iron siphons pass under the subway to the discharge chamber. Under normal conditions of flow, the sewage fills the chamber behind the dam and is drawn away by the 14-in. siphon, but in times of storm flow the sewage and rain water overflow the dam and are drawn away by the two 42-in. siphons, as well as by the 14-in. siphon. The various details of the construction which has been described are so clearly shown by the drawings that further description is unnecessary.

SUBSURFACE CONDITIONS. — The subsurface conditions encountered in carrying out the sewer diversion work are of incidental interest, owing to the vast network of conduits of all sizes and ages and for all purposes which underlie the city streets. In some places these conduits formed a veritable roof over the excavation. All of these pipes had to be supported and protected from injury during the work, and many of them had to be reconstructed in new locations. Perhaps the most significant discovery in some respects was the condition in which many of these conduits were found. The wily contractor and his equally subtle cousin, the plumber, had got in their fine work in many places, and the state of affairs disclosed by the excavations was both curious and deplorable. In some places rock which should have been excavated the full width of the trench was found to project inward so as to overlap the sewer. Many of the sewers were laid directly on the rock bottom of the trench, although the specifications under which the work was done called

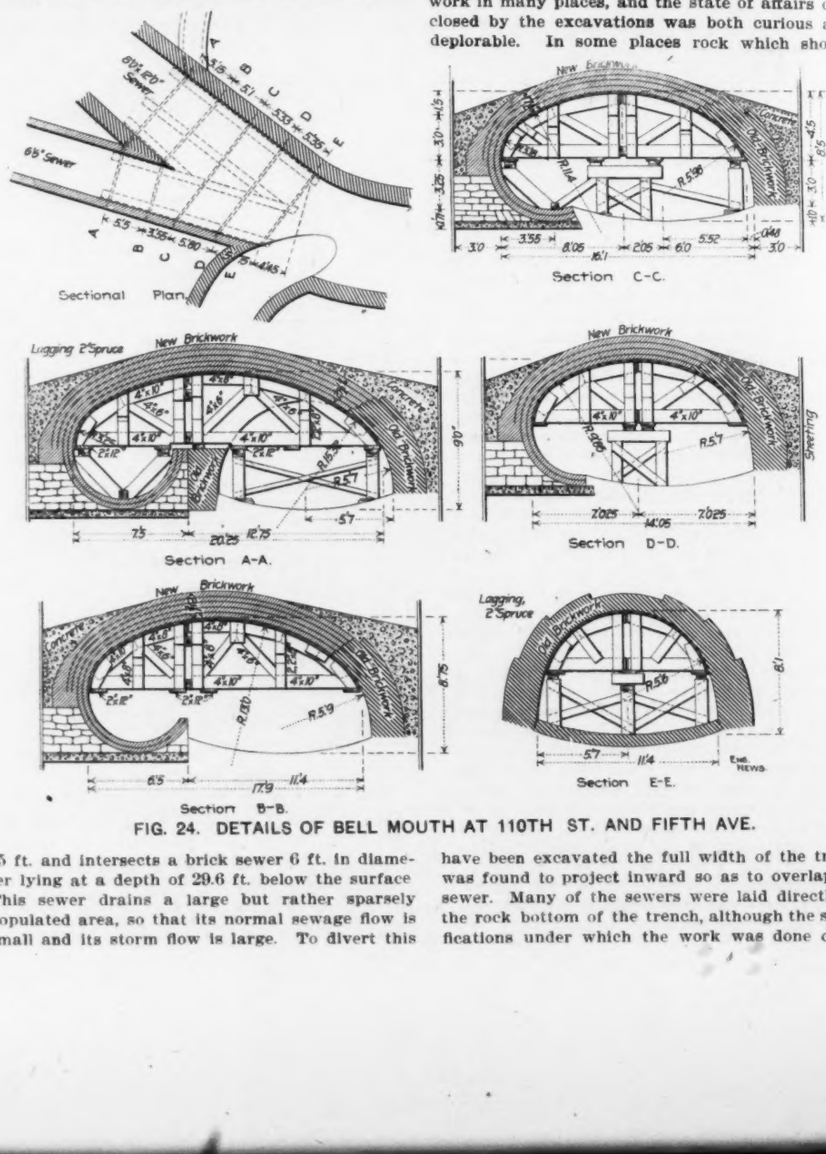


FIG. 24. DETAILS OF BELL MOUTH AT 110TH ST. AND FIFTH AVE.

for a 1-ft. bed of sand and gravel. In two instances of 11-ft. circular sewers were found to have but one ring of bricks. Another frequent circumstance was the laying of the invert brick without mortar joints. In the matter of alinement it was frequently found that tangents on the engineers' plans had assumed under the contractors' hands a meandering curve of ingenious irregularity. In putting in the house connections the plumber had

FIG. 25. INTERIOR VIEW OF BELL-MOUTH AT 110TH ST. AND FIFTH AVE.

outvied the contractor in doing slipshod work. A typical instance was the construction of the connection by breaking a hole through the sewer and sticking the house pipe through it so that it projected inside and often pointed upstream.

RECORDS OF WORK.—In carrying out the work of sewer diversion an elaborate system for keeping records of the work done and of the underground conditions is followed. This system is too elaborate and of too special interest to be described in detail, but it should not pass without some mention. In brief, photographs are taken to show, first, the original conditions, and, second, the altered conditions; progress profiles in colors show the location of each piece of work and the weekly progress made in carrying it out; the progress profiles are supplemented by tables showing definitely the exact amounts represented graphically by the profile; estimates are kept of the cost of construction and of materials, including a daily time account of the labor; finally, when the work is completed, sectional profiles and plans are prepared for each piece of work, which show every pipe and obstruction which originally existed, and also every new pipe, alteration and house connection in the new work.

THE VALUE OF MODERN TOOLS FOR RAILWAY SHOPS.*

By M. K. Barnum.†

The amount of money that is wasted every day by the lack of "up-to-date" tools is appreciated by very few railway officials. Even many superintendents of machinery and master mechanics do not fully realize the saving that can be effected by replacing worn-out and obsolete machines with others which are strictly "up-to-date" and fitted with all the latest improvements. If an old machine can be replaced with a new one which will do enough more work or do the same work with enough less labor to represent a saving in money equal to 5% per annum on the investment, it should be entitled to careful consideration, as this is the basis on which other railroad improvements are figured. How easy then, ought it to be for mechanical men to obtain approval on a requisition for a machine which will save from 10% to over 100% per annum on the investment. A few actual examples of such savings may be needed to convince those who have not studied this question, or others who have not had the new machines to compare with old ones.

1. In a railway shop employing about 160 machinists there were no horizontal boring machines for such work as boring driving-box brasses, rod brasses, rocker boxes, air-pump cylinders, etc., and all such work had to be done in lathes, milling machines or drill presses. After repeated conferences and much argument, accompanied by estimates of savings that would result, permission was obtained to order a horizontal boring and drilling machine with 4-in. bar and latest attachments. It has been in use about 18 months and shows earnings by money saved as follows: Original cost of machine installed ready for work, $1,696; average savings per year as compared with old manner of doing same work, $800; interest on investment, 53%. It formerly required three hours to bore a driving-box brass for a 9 × 12-in. journal in a milling machine and about four hours to do the same work in a lathe, whereas they are now bored in one hour in the horizontal boring machine. Rocker boxes, tumbling-shaft boxes, etc., are done in half the time formerly used. In boring air-pump cylinders it was formerly necessary to take the pump apart and set and bore each cylinder separately, requiring from two to three hours each. In the new machine it is possible to bore all four cylinders of a New York brake pump at one setting, without taking them apart, and requires but an average of one hour for each cylinder. In addition to the saving in time, much greater accuracy is insured. It is very conservative to say that this machine does double the work of the old ones, thereby saving the wages of one machinist at $3 per day for 300 working days, or $900 per year.

2. An old car wheel borer was replaced by a new, heavy 42-in. borer with hub-facing attachment, power crane for handling wheels, etc., which cost installed, $1,711. This wheel borer saves the wages of one helper three hours a day and does more than double the work of the old machine, making a total of $2.45 per day, or $735 a year, which amounts to 42½% on the investment.

3. A new heavy double-head car-axle lathe, costing $1,665 installed, turns out one-third more work than the old one on account of taking a heavier cut and heavier feed, thereby saving about $250 a year, or 15% on the principal.

A long list of such examples could be given to show the increased earning power of machine tools, which are strictly up-to-date. Tools are not up-to-date when there is something else on the market which will do more work or do it at less cost of labor. They need not necessarily be worn out to be wasteful by comparison.

Most engine lathes of modern design have greater power, weight and strength to withstand heavier cuts and coarser feeds than those built 20 or 25 years ago, which enables the former to turn out from 20 to 30% more work. This represents savings equal to from 15 to 35% interest on the investment, varying with the cost of the lathe and the class of the work for which it is used.

Recent planers are built 30 to 50% heavier than they were 20 years ago, with greater power and quicker return, the latter running as high as 72 to 80 ft. per minute as compared with 40 ft. or less for the older machines. They are also fitted with three or four tool heads, whereas the old planers had only one or two at most. This means an increase of 25 to 50% in the amount of work done, or earnings of 10 to 25% on the amount expended for the machine.

The various types of turret lathes for making bolts, studs and pins from bar iron are well adapted to locomotive work and will easily turn out twice or three times as much of this class of work as will an ordinary old style engine lathe. Such machines cost $1,600 to $1,800, and make a return of from 50 to 60% in savings. The large automatic turret lathes for turning piston heads, cylinder packing, bull rings, balanced valve rings, etc., will do double the amount of this work that an engine lathe will, and the same may be said of the latest boring and turning mills.

Many improvements have been made in drill presses, among which may be mentioned easier and quicker adjustments of both spindle and work, swiveling tables, tapping attachments, multiple spindle drills, variable speed countershafts, etc., all of which help to increase the output.

Milling machines are great time savers on certain classes of work which used to be done on slotters, shapers or planers and are especially economical where a large number of duplicate parts are to be made. Every tool room ought to have at least one universal milling machine and there are various jobs of locomotive work that can be done to great advantage on such machines. The percentage of saving to be obtained depends not only on the original cost and amount of additional work done, but also on the rate of pay and skill of the operator and the number of hours the machine is run. As a rule, improved small tools will therefore earn a larger rate of interest on the investment than larger and more expensive ones.

There are very few railways to-day which have not

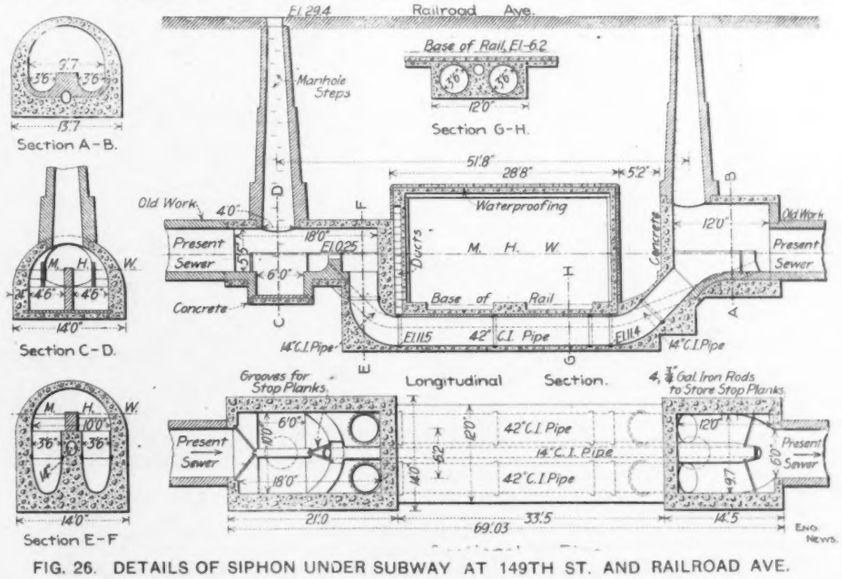


FIG. 26. DETAILS OF SIPHON UNDER SUBWAY AT 149TH ST. AND RAILROAD AVE.

*Abstract of a paper read before the Western Railway Club, at the meeting in Chicago, March 18.

†Master Mechanic, Union Pacific Ry., Omaha, Neb.

more or less pneumatic drills, hammers, riveters, hoists, etc., and no argument should be necessary to demonstrate their earning capacity, but the value of air jacks for cars and locomotives is not so generally known. It formerly required about four hours for eight men with screw jacks to take a ten-wheel engine weighing 132,000 lbs. off its drivers, at a cost of $5.14, and about half that time for four men to do the same work with hydraulic jacks, but using four pneumatic jacks, it is now regularly

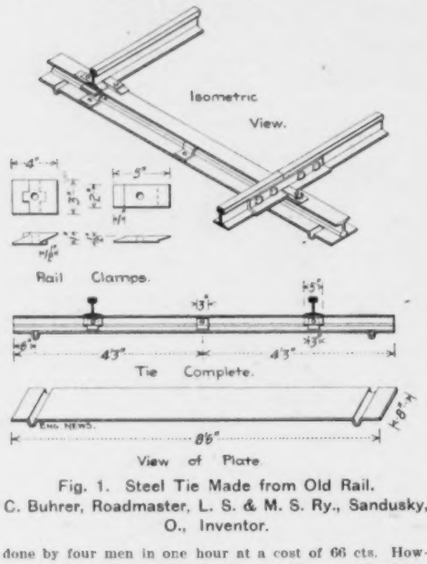


Fig. 1. Steel Tie Made from Old Rail.
C. Buhrer, Roadmaster, L. S. & M. S. Ry., Sandusky, O., Inventor.

done by four men in one hour at a cost of 66 cts. However, to be strictly up-to-date an electric crane should be used and the time reduced to ten minutes.

A pneumatic ram was recently made at a cost of $168.55 for breaking staybolts to remove worn-out fire boxes, which earns very large interest on the investment. It formerly cost $45.00 to cut out the crown bolts and staybolts of a ten-wheel locomotive with 9-ft. firebox, using three men, but with the pneumatic ram it is done by two men for $15.20, thereby saving $30.40 on each firebox. If only one firebox was removed each year this tool would earn 18% on the investment, but as this shop applies 30 new fireboxes a year the saving amounts to $912, or 541% per annum on the amount invested.

The improvements and radical departures from old practice in the manufacture of machine tools for metal working, have been much greater than in wood-working machinery; but recent designs of planers, tenoners, molding and mortising machines are much heavier and more powerful and will do from 25 to 50% more work than old machines. The hollow chisel mortiser is an ingenious and very profitable tool for any shop, and the four and six-spindle boring machines are great labor savers. Wood trimmers are most valuable additions to the equipment of cabinet or pattern shops, and the new pattern and corebox machines will easily earn 100% on their cost if used one hour a day.

In figuring the earnings of the "up-to-date" tools in the above example, only average results have been taken and not special cases of unusual savings. No credit has been allowed for the scrap value of old machinery thrown out, nor have we considered the saving in shop room due to the use of more efficient tools; and last, but not of least importance in railway work, is the reduction in the number of days locomotives must be held out of service for repairs, which will follow the use of up-to-date machinery.

In a certain shop which makes general repairs to about 100 locomotives a year the average length of time required to put each engine through the shop was reduced from 34 days in 1898 to 30 days in 1900. This represents a saving of 640 days for one locomotive which, at a rental value of $10 a day, gives $6,400. As this was done with the addition of only a few new machines in a shop full of old and worn-out tools, many of which had been in service from 25 to 35 years, you can readily understand how much greater saving could be effected had the shop been fully equipped with up-to-date machinery.

STEEL TIES ON THE LAKE SHORE & MICHIGAN SOUTHERN RY.

A short section of track on the Lake Shore & Michigan Southern Ry., near Sandusky, O., has been laid with steel ties, and while this cannot be taken to indicate any activity in the steel tie question (as noted in another column), it is worth while putting on record.

The ties in question are the invention of Mr. C. Buhrer, of Sandusky, Division Roadmaster of the L. S. & M. S. Ry., and are designed to utilize old rails. The original design was for the rails to be re-rolled to an I-beam section, 5 ins. wide over the top flange, 8 ins. over the bottom flange and 3 ins. high. They have not yet been made in this way, however, owing to the expense of turning special rolls. The ties as actually made are shown in Figs. 1 and 2. An old 65-lb. rail (4 ins. high and 4 ins. wide) is cut into lengths of 8 ft. 6 ins., each length forming the body of one tie, and being inverted. Under the head is a ¼-in. steel plate, 8 ins. wide and 8 ft. 6 ins. long, with two transverse ribs to get a grip in the ballast. The plate is secured to the rail by three pairs of angle brackets riveted to the base plate, and shaped to fit the rail and web, to which latter they are bolted. Under each track rail are two short pieces of angle bar bolted to the tie by the same bolt that holds the plate connections, and these (with the base of the old rail) form the seats for the track rails. Each track rail is secured to the tie by two clamps bolted to the base of the old rail of the tie. It will thus be seen that the tie, exclusive of rail attachments, consists of 12 parts, put together with three bolts and six rivets, or 21 parts in all. As the number of parts and the amount of shop work required in putting them together materially influence the cost and durability of a steel tie, it will readily be seen that while this tie may prove serviceable, it cannot well compare with simpler forms from a commercial point of view. Of course, the proposed tie rolled in one piece, as already referred to, would be quite a different proposition.

The old rail weighs about 170 lbs. and the steel plate and angle brackets about 70 lbs.; making the total weight about 240 lbs. for the ties now in use. The rolled tie would weigh about 170 lbs. The cost of the built-up tie varies, of course, with the price of scrap rail and plate, but is given by the inventor as follows: Scrap steel rail at ¾-ct. per lb., $1.27; plate, brackets, rivets and labor of fastening plates and drilling rail, $1.65; total, $2.92. Against this he offsets a scrap value of $1.79, at ¾-ct. per lb. for the full original weight of 240 lbs., the element of reduction of weight by wear or corrosion being disregarded. Assuming a life of 30 years, the steel tie would outlast four sets of oak ties, costing $2.40 at present prices, or $2.85, allowing 15 cts. for the placing of three new sets of ties in the track. This does not take into account the saving due to the roadbed being left undisturbed during the life of the steel tie. Under present conditions of railway working, a price of $2.92 in purchasing ties would, of course, be quite prohibitive. The price of the rolled tie is not given, but Mr. Buhrer's idea is for railways to utilize their scrap rails, although [illegible] of a similar section could, of course, be rolled from blooms in the usual way.

There were eight of these ties laid in the yard at Sandusky in May, 1900, and 150 more were laid in May, 1901, in the southbound main track on a curve 2½ miles east of Sandusky, where trains run at a high rate of speed. This piece of work is shown in Fig. 3. The ties are spaced 20 and 24 ins. c. to c., and are laid in gravel ballast, replacing oak ties 7 to 9 ins. thick. Mr. Buhrer calls attention to the amount of ballast under the bottom flange of the tie, which practically increases its weight, and remarks that the ties of inverted trough section so extensively used abroad cannot be tamped solid. This is not correct, as little trouble is experienced with the tamping of either stone or gravel in these ties, while the bal-

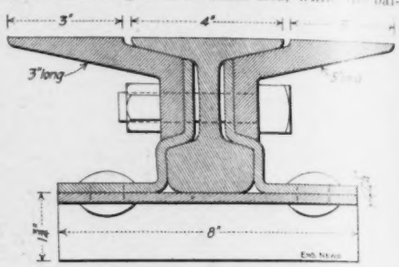


Fig. 2. Cross-Section of Steel Tie.

last is also filled in level with their tops. As the ends of the trough are usually closed, the end bearing in the ballast and the friction of the enclosed core of ballast upon the ballast below the tie serve to prevent lateral shifting of these trough ties. In Mr. Buhrer's built-up tie, the ribs across the base plate are relied upon to prevent lateral motion, but his rolled ties would apparently have no such provision, unless some form of anchor is to be attached.

FIG. 3. TRACK LAID WITH STEEL TIES; LAKE SHORE & MICHIGAN SOUTHERN RY.

The Severac steel tie, at one time extensively used in Belgium, somewhat resembled the Buhrer tie. It was made of a piece of I-beam, 4¾ ins. high, 3¼ ins. wide over the flanges, and 8½ ft. long, with a base plate 0.32-in. thick and 9½ ins. wide riveted to the bottom flange. The ends of the plate were turned up vertically against the ends of the I-beam to afford resistance to lateral motion in the ballast. The weight was 150 to 204½ lbs. per tie, according to the dimensions. Defects in the rail fastenings led to the abandonment of most of these ties.